MECHANICAL FILTRATION PLANT
FOR
WAUKEGAN, ILLINOIS

BY

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I. M. SEVIN

ARMOUR INSTITUTE OF TECHNOLOGY

1914

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DESIGN OF A MECHANICAL FILTRATION PLANT

FOR

WAUKEGAN, ILLINOIS.

A Thesis Presented

by

M. S. Willens

I. M. Levin

To

The President and Faculty

of

Armour Institute of Technology

For the Degree of

Bachelor of Science in Civil Engineering

Having Completed The Prescribed Course

In

Civil Engineering.

Chicago, Illinois.

May - 1914.

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Thesis.

Design of a Mechanical Filtration Plant for Waukegan, Illinois.

From a report of the State Water Survey, the present water works difficulties of Waukegan result from three causes.

1st. The impurity of the water as drawn from Lake Michigan at point of intake.

2nd. The insufficiency of the size of the intake pipe.

3rd. Clogging by anchor and frazil ice.

Intake Improvements.

There are two ways suggested in which improved intake facilities can be obtained which will insure satisfactory results, namely, an extended and permanent intake, or an emergency intake into the harbor. As for the permanent intake, the objection to it is that the cost will be excessive, the improvement will require too much time, a sufficient quantity may not be able to be received and the quality of water will not be satisfactory. The emergency intake into the harbor is thought to be a good idea and is at present being

constructed. It will extend to a point in the harbor where a change in the in-shore and of the south break-water has formed a small bay of comparatively deep water which is in-accessible for navigation. The in-take structure at this point will be free from anchor ice troubles, because the surface of the water being protected by the break waters would always be frozen over before the season of ice troubles arrives, and once frozen over, formation of anchor or frazil ice is extremely unlikely. The water can by no means be used as a permanent source at present, on account of the contaminations existing there from vessels and other causes, but with a purification system the water may be used without any trouble.

The State report shows turbidity for the last 8 months averaging 40 parts per million with a maxi-mum of 325 parts in November. The average bacterial counts for the same period were 2300 per cc. with 50% of the 1cc. samples showing tentative positive B. Coli indications. After bleach treatment which is used there at present, the bacteria averaged 115 per cc., and 8% of the samples tested gave the gas reaction test for

B. Coli. This shows the necessity of installing a mechanical filtration plant which would treat the water from either or both intakes.
Population at present 17000.
Minimum consumption in 1912 ..... 2,865,000 Gal. per day.
Maximum " " " ..... 4, 560,000 " " ".
Average " assumed as 4,000,000 " " ".

In order to take care of the maximum consumption and to be reasonably safe, the filter works will be designed for 6,000,000 gallons capacity. This is an adequate amount, for with the present population of 17,000, it is certain that a great deal of the present rated consumption represents water used carelessly, and hence, when water meters are installed throughout the town, the consumption will drop considerably below the present figured amount. Also with the normal rate of filtration kept low so that it may be increased if desired, and with space left for the addition of two filter tanks in the future, a reserve period of at least 30 years is provided for.

DESIGN.

Hydraulics.

Pump Room.

Two motor driven centrifugal pumps will be used as such on cut, so that they may be operated singly or in series.

Maximum Capacity of each is 3,000,000 gallons per day or $\frac{3,000,000}{24 \times 3600 \times 7.48} = 4.65$ cu. ft. per sec.

A single suction pipe will be lead from the wet well to the pumps.

Available head = 10' = H

$D = .479\left(\frac{[(1+E_0)D+fL]Q^2}{H}\right)^{\frac{1}{5}}$

Assume D = 1.5', f = .02, E_0 = .5, L = 150'

Therefore $D = .479\left(\frac{[(1+.5)1.5+.02\times150]9.3^2}{10}\right)^{1/5}$

D = 1.43 or say 18" cast iron pipe.

Pumps were picked from H.R. Worthington Catalogue. A 5,000,000 gallon pump was also picked for a wash water pump. The pumps are to be motor driven, for the speeds of the motors can be regulated at times when head and capacity are subject to change. Also greater efficiencies can be obtained with motors then with steam turbines for heads as low as exist here, which is a maximum of 20'.

Single Suction Volute Pump.

Normal capacity = 3300 gallons per min.

Dimensions 4 ft. – 7 in. long, 4 ft. – 4 in. wide, and 4 ft. – 0 in. high.

Discharge pipe = 8"

Valve operation will be done on floor above.

A venturi meter to fit discharge pipe will be inserted between pumps and chamber. All indicating and registering devices will run to operating floor of head house.

Chemical Room:

This room will contain a complete equipment for the preparation and application of solutions of coagulating chemicals.

Extreme maximum discharge - 7,000,000 gallons per day.

Alum, sufficient to produce desired precipitation in Lake Michigan water is 1 grain per gallon.

Therefore, the most ever needed per day = $\frac{7,000,000}{7,000}$ #

Weight per cu. ft. taken same as water.

Gallons of alum per day = $\frac{1,000}{8.3}$ = 121 -

Two storage tanks will be used, each of 4,000 gallon capacity, giving sufficient chemical solution for 66 days with average conditions and for 33 days with maximum conditions. Two solution pumps will be used,

each to have a maximum capacity of 150 gallons per day.

Coagulation Chamber.

The size of this chamber was made large enough to serve as an equalizing chamber. Weirs will be cut through the wall at each end in order to provide overflow to chambers adjoining. Maximum discharge =6,000,000 gallons per day, or 9.30 cu. ft. per sec. On each side discharge = 4.65. From formula $Q = 3.33\ L\ H\ 3/2$, H being assumed as .5 ft., L = 3.5'. If quantity becomes smaller or greater H correspondingly changes, therefore weir made 3.5'x 2.5'.

Mixing Chamber.

This chamber was made of a size sufficient to bring about an interrupted flow of the water between baffle walls, the result of which will be a thorough mixing of the chemical solution with the water.

Settling Chamber.

The basins were made large enough to give the desired length of travel of the coagulated water, and thereby remove the bulky coagulum formed. Size of one basin = 43'x50'x15' or 32,250 cu. ft., which gives a capacity of 32,250x7.5 or 242,000 gallons. Velocity of flow through basin, under maximum conditions = $\frac{4.65}{20x15}$ or .0155 ft. per sec., which is

approximately 60 ft. per hour. Since basin is 50 ft. long it will take $\frac{50}{60}$ of 1 hour or 50 minutes for water to travel across basin, which is sufficient time for settling of precipitate.

The other basin is $32 \times 50 \times 15 = 24000$ cu. ft. or 180,000 gallon capacity. Velocity through it same as above and hence O.K.

Filter-house —— Filter beds.

6,000,000 gallons between 6 filter beds makes filter capacity of each bed, 1,000,000 gallons per day. Rate of Filtration = 125,000,000 gallons per acre per day $= \frac{125,000,000}{43560 \times 60 \times 60 \times 24} = 2.00$ gallons per sq. ft. per min. or 2880 gallons per sq. ft. per day.

Size made 18'x20' or 360 sq. ft. which will allow a slight variation. For average conditions the filtration per day is half that figured and must be obtained by the regulation of the rate controller described in Specifications. Head over sand bed to produce rates desired, figured from Hazen's Formula

$$V = cd^2 \frac{h}{l} \left(\frac{t + 10^\circ}{60^\circ}\right)$$

where V = (app) million gallons per acre per day,

c = constant ranging between 400 and 1000

d = effective size of sand which is taken as .35

h = head causing motion

l = thickness of sand layer

t = temperature in Fahrenheit degrees taken as 50°

Take h/l = 1, then $125 = 1000 \times .35^2 \times 1 \times 1$

$$125 = 125.$$

This gives 30" of water as head lost to start which will increase when sand becomes clogged, up to 10'. Sufficient head is provided for, in the location of the pipe discharging from the settling chamber, to take care of the maximum friction head necessary to produce maximum rates desired.

Operating Gallery.

A number of pipes must be used to deliver and take away water from filter tanks.

Coagulated water main. ———

$$Q = \frac{7,000,000}{7.48 \times 24 \times 3600} = 10.9 \text{ cu. ft. per sec.}$$

Q = A×V. V assumed as 2.5 ft. per sec.

Therefore, A = 4.2 sq. ft.

A reinforced concrete conduit 2' square and 4" thick will be used. I picked this from a table in the Eng. Record. Reinforcing bars will be placed as shown on drawing. The discharge becomes smaller along the filter house and hence V becomes smaller. For laterals

$$Q_{\text{max.}} = \frac{2,000,000}{7.5 \times 3600 \times 24} = 3.10 \text{ cu. ft. per sec. From}$$

Chesy's Formula $D^5 = \frac{@ Q^2 L}{\pi^2 h/16} = \frac{.00064 \times 3.10^2 \times 10}{9.87 \times .25/16} = .85'$, call ~~1'~~ D 12"

where D = diameter

Q = discharge

L = length

h = head lost in friction, assumed as .25'

C = constant

A 12" Cast Iron pipe will be used.

Effluent Main.—— A reinforced concrete conduit 2' square and 4" thick will be used. I picked this from a table in the Eng. Record. For laterals $Q_{max} = \frac{1,000,000}{7.5x3600x24}$ = 1.55 cu. ft. per sec.

$$D^5 = \frac{CQ^2L}{\pi^2 h/16} = \frac{.00064x2.4x10}{9.87x.25/16} = .131 \quad D = .69' \text{ call it } 10".$$

A 10" Cast Iron pipe will be used.

Wash water pipe. —— For wash water pipe, if high rate wash water is used, water must be pumped at rate of 15 gallons per sq. ft. per min., or since filter bed area = 360 sq. ft., total pumpage = 5400 gallons per min., or $\frac{5400}{7.5x60}$ = 12 cu. ft. / sec.

Max. head = 15' Max. L = 120'.

$$D^5 = \frac{CQ^2L}{\pi^2 h/16} = \frac{.0006x144x120x16}{9.87x15} = 1.18 \text{ sq. ft., call } \overset{D}{\cancel{H}} \; 12".$$

Laterals of same size for total quantity goes to each filter bed separately.

Waste pipe lateral must receive from each filter bed after cleaning, the quantity used in washing bed, that is 12 cu. ft. per sec. This has gravity fall to waste water main.

$h = .25$ $L = 7'$

$D^5 = \frac{.0006 \times 144 \times 7 \times 16}{9.87 \times .25} = .42'$ $D = .83'$ call it 10" C. I. pipe.

For main, slope to sewer will be 8' in 80'.

Therefore, $D^5 = \frac{.0006 \times 144 \times 80 \times 16}{9.87 \times 8} = 1.44$ sq. ft. $D = 1.05'$.

A 12" C. I. pipe will be used.

Lateral for wasting effluent. $Q = 1.55$ cu. ft. per sec.

$D^5 = \frac{.0006 \times 2.4 \times 7 \times 16}{9.87 \times .25} = .099$ $D = .62'$, will use an 8" C.I. pipe.

Main pipe.

$D^5 = \frac{.0006 \times 2.4 \times 100 \times 16}{9.87 \times 2} = .121$ $D = .68'$.

Will use 8" C. I. pipe.

For connection to coagulated water main from settling basin, an 18" C. I. pipe coated with concrete will be used in one basin, and an 18" hole will be placed in wall of other basin adjoining the pipe gallery.

Reinforced Concrete.

Roofs.

Slabs:—

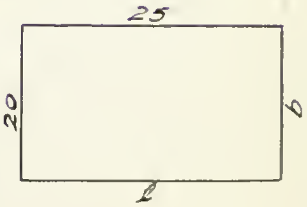
Take total loading of 150# per sq. ft.

Will use slabs reinforced in both directions.

For mixing chamber slab = 20'x25'.

$l/b = 25/20 = 1.25$.

From table in Turneoure & Maurer



Transverse system carries .71 of load

Long. " " .29 " "

Tran. $M = 1/12 \times .71 \times 150 \times 20 \times 20 = 3550'\#$

Long. $M = 1/12 \times .29 \times 150 \times 25 \times 25 = 2270'\#$

$M = Rbd^2$, $d = \sqrt{\dfrac{3550 \times 12}{98 \times 12}} = 6"$ will use 8" and make total 9",

depth for transverse steel = 8.0 - 1.5 = 6.5"

$$a = \frac{M}{f_s jd} = \frac{3550 \times 12}{15000 \times .87 \times 6.5} = .502.$$

Will use 9/16" ~~1/2~~ rods spaced 6" c.t.c.

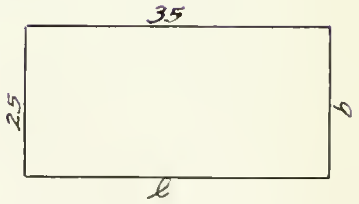
For longitudinal steel $a = \dfrac{M}{f_s jd} = \dfrac{2270 \times 12}{15000 \times .87 \times 8} = .243$

Will use 5/8" rods spaced 12".

This slab spans walls on all sides and hence no beams or columns are necessary.

Slab over equalizing and pump room = 35'x25'

$l/b = 1.4$



Trans. system carries .8 of load

Long. " " .2 " "

Trans. $M = 1/12 \times .8 \times 150 \times 25 \times 25 = 6250'\#$

Long. $M = 1/12 \times .2 \times 150 \times 35 \times 35 = 3060'\#$

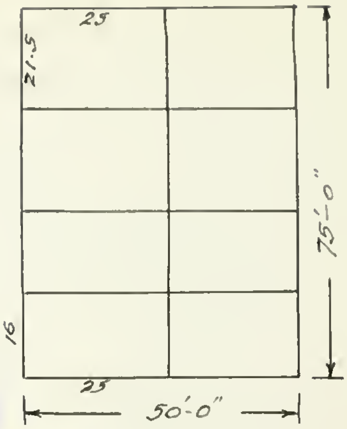
$d = \sqrt{6250/98} = 8"$, total 9"

d for trans. steel = 6.5"

$a = pbd = .0075 \times 12 \times 6.5 = .585$

Will use 5/8" rod spaced 6".

For long. steel $A = M/f_s jd = \dfrac{3060 \times 12}{15000 \times .87 \times 8} = .332$



Will use 9/16"rods spaced 12"

Over settling basin one slab =

= 25'x21.5'

l/b = 1.16

Trans. system = .64 of load

Long. " = .36 " "

Trans. M = 1/12x.64x150x25x25= 5,000'#

Long. M = 1/12x.36x150x21.5x21.5 = 2080'#

d = 5000/98 = 7"

Will use same thickness as figured before.

Area of trans. steel = M/f_sjd = $\frac{5000x12 =}{15000x.87x6.5}$ = .706

Will use 5/8" rods spaced 6'

For long. steel A = M/f_sjd = $\frac{2080x12}{15000x.87x8}$ = .24

Will use 5/8" rods spaced 12"

For 25'x16' slab

Trans. system carries .85

Long. " " .15

Trans. M = 1/12x.85x150x16x16 = 2720'#

Long. M = 1/12x.15x150x25x25 = 1175'#

Will use same thickness as before

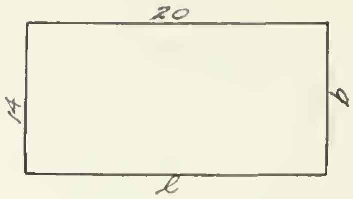
a for trans. steel = $\frac{2720x12}{15000x.87x6.5}$ = .385

Will use 5/8" rods spaced 12"

a for long. steel = M/f_sjd = $\frac{1175x12}{15000x.87x8}$ =.135 sq. in.

Will use 5/8" rods spaced 12"

Over filter beds slab is 14x20'



l/b = 1.43

Trans. system carries .81

Long. " " .19

Trans. M = 1/12x.81x150x14x14 = 1985'#

Long. M = 1/12x.19x150x20x20 = 950'#

Will use same thickness as figured before.

Area of trans. steel = $M/f_sjd = \frac{1985x12}{15000x.87x6.5}$ = .28 sq. in.

Will use 7/16" rods spaced 8"

Area of long. steel = $\frac{950x12}{15000x.87x8}$ = .11 sq. in.

Will run through every other rod of roof of settling basin 5/8" rods spaced 24".

Roof over operating gallery and head house to be made same as regular flat roofs of other parts of plant.

Beams:

Longitudinal beam.

.64wbl/2 = .32 wbl = .32x150x25x21.5 = 25800# = R

M = 25800 (12.5-4.7) = 201,500'#

W = 21.5x150 = 3220#

12.5x3220 = 40,300# = V

V/100 = 403 = bd t = 9" flange width = 4'-0"

let b = 3d/4

Therefore, $d = \frac{4x403}{3} = 22"$ total 24" $b = 18"$.

From table in T and M f_c is below allowable value and O.K.

$A = \frac{201500x12}{15000x.87x22} = 80$ sq. in.

Will use 8 – 1" rods spaced 2" leaving 2" of concrete on each side.

Stirrups take 60#

$P = 60x40xd/4 = 60x40x6 = 14400\#$

$2\ A\ f_s = 14400\quad A = .6$ sq. in. or will use a 3/4" rod.

$= V/vjd = \frac{40300}{115x.87x24} = 16.7"$

For compressive steel will turn up 4 rods each side of support. $f_c = 430\#$ $f_s = 14500\#$. Therefore, O.K.

This is max. condition of loading and will use this beam throughout.

Transverse beam:——

$.36/2 = 18\ wbl = 18x150x25x21.5 = 14{,}500\# = R.$

$M = 14500\ (11 - 4.1) = 100{,}000'\#$

$W = 25x150 = 3750\#$

Shear $= \frac{3750x21.5}{2} = 40{,}300\#$

Will use same beam as one in longitudinal direction.

$A = \frac{100{,}000x12}{15000x.87x22} = 4.07$ sq. in.

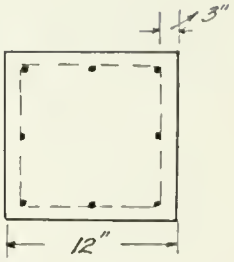
Will use 8 – 1/2" rods spaced 2"

Will use same stirrup as above.

Will turn up 4 rods as before. O.K.

Columns: ——

For maximum conditions of loading.



$P = 2x14500 + 2x25,800 = 80,600\#$

$P' = f_c A \{1 + (n - 1)p)$

f_c assumed as 600# n = 15 and p = .015

A = $\frac{80,600}{726}$ = 111. Will use a 12" sq. column.

Area steel = .015x110 = 1.66 sq. in.

Will use 8) – 3/8 in. sq. rods spaced 4½".

Floors.

Settling basin:——

Loading = weight of water weight of slab weight of roof and live load = 75x50x17x62.5 + 75x50x1.5x150 + 75x50x100 = 4,937,500#. Load per sq. ft. = $\frac{4,937,500}{75x50}$ = 1320# per sq. ft.

Filter house — over filter beds.

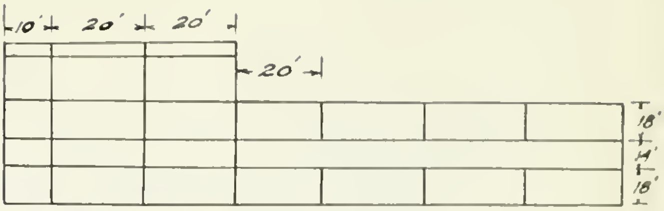
Loading = water weight sand and gravel weight weight of slab, roof and live load = 80x18x44150 + 80x18x11x62.5 + 80x18x1.5x150 = 1,990,000#

Load per sq. ft. = $\frac{1,990,000}{1440}$ = 1320 # per sq. ft.

Therefore loading will be taken as 1320# per sq. ft.

Slabs reinforced in both directions.

18'x20' slab



$1/b = 20/18 = 1.11$

Trans. system carries .59

Long. " " .41

Trans. M = 1/12x.59x1320x18x18 = 21000'#

Long. M = 1/12x.41x1320x20x20 = 18050'#

$M = Rbd^2$ $d = \frac{21000}{98}$ = 14.5" total 16"

depth to transverse steel = 14.5 – 1.5 = 13"

a = pbd = .0075x12x13 = 1.17 sq. in.

Will use 3/4" rods spaced 5 1/2"

For long. steel $a = M/f_s jd = \frac{18050x12}{15000x.87x145}$ = 1.16 sq. in.

Will use 3/4" rods spaced 5 1/2".

Since this is max. condition of loading, transverse steel will be placed at 13" and longitudinal steel at 14.5" throughout.

14'x20' slab. $1/b = 1.43$

Trans. system carries .81

Long. " " .19

Trans. M = 1/12x.81x1320x14x14 = 17,500'#

Long. M = 1/12x.19x1320x20x20 = 8,360'#

$M = Rbd^2$ Therefore, $d = \frac{17500}{98}$ = 13.5.

A to transverse steel = 12"

A = pbd = .0075x12x12 = 1.08 sq. in.

Will use 3/4" rods spaced 5 1/2" and placed at 13"

For long. steel $a = M/f_s jd = \frac{8360x12}{15000x.87x13.5}$ = .56 sq. in.

Will use 3/4" rods spaced 12".

In 14'x10' slab area of transverse steel = .0465 sq. in., and running through a 3/4" rod every 72" from 14x20 panel is sufficient. For long. steel, area = .025, which is taken up by running 1 rod through the center of the panel.

For 18'x10' slab, running through a rod every 72" from 18'x20' panel is sufficient for transverse steel, and 1 rod through center as explained above, is sufficient for long. steel.

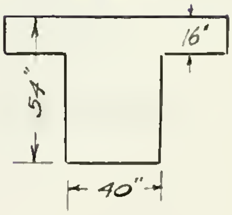
For 7'x20' and 7x10'panels the same thing was done as above.

Beam: —

Longitudinal beam.

$\frac{.81\ wbl}{2} = .405\ wbl = .405 \times 1320 \times 14 \times 20 = 150{,}000\#$

$M = 150{,}000 \times (10 - 7.50) = 470{,}000'\#$ which is maximum.



$W = 16 \times 1320 = 21{,}120\#$

$V = 10 \times 21{,}120 = 211{,}120\#.$

$V/100 = 2110\# = bd \quad t = 16"$

let $b = 3d/4$

$d = \frac{4 \times 2110}{3} = 54"$ and $b' = 40"$

$M/bd^2 = \frac{470{,}000 \times 12}{40 \times 54 \times 54} = 49 \quad t/d = 16/54 = .296$

From T. and M. $f_c = 400\# \quad jd = 47.$

Therefore, $A = M/f_s jd = \frac{470{,}000 \times 12}{15000 \times 47} = 8$ sq. in.

Will use 9-1" rods spaced $4\frac{1}{2}$".

$V = \frac{211120}{40x54} = 98\#$.

Stirrups take 98-40 = 58#.

$P = 58x40x\frac{d}{4} = 58x40x14 = 38,500\#$.

$2Af_s = 32,500$.

Therefore A = 1.35 sq.in. and $1\frac{1}{4}$" sq. rod will be used.

$= V/wjd = \frac{211120}{115x47} = 39$.

For compressive steel 5 rods will be turned up each side of support.

$p' = \frac{10}{40x54} = .0046 \qquad p = \frac{8}{40x54} = .0037$.

$j = .87 \qquad K = .3$.

$f_s = \frac{470,000x12}{.0037x.87x40x54x54} = 15000\#$. O.K.

$f_c = \frac{15000x3}{15x7} = 430\#$. O.K.

Transverse beam.

$\frac{.41wbl}{2} = .205\ wbl = .205x1320x18x20 = 97,200\#$.

M = 97,200 (9-6.76) = 273,000'# which is maximum.

w = 20x1320 = 26,400#.

V = 9x26,400 = 237,600#.

$\frac{237,600}{100} = 2376 = bd$.

Let $b = \frac{3d}{4}$. d = 4x2376/3 = 56" and b = 42",t = 16".

$M/bd^2 = 25$ $t/d = .286$ from table $f_c = 250\#$ $jd = 50.5$

$$A = \frac{273000\text{x}12}{15000\text{x}50.5} = 4.3 \text{ sq. in.}$$

Will use 7 – 13/16 in. square rods spaced 6 in.

V for stirrups = 61#

P = 61x42x56/4 = 36000#

$2\ Af_s = 36000$ A = 1.5 sq. in. and 1.5 in. square rod will be used.

For negative bending moment 6 rods will be turned up each side of support.

$f_s = 15100\#$

$f_c = 400\#$ O.K.

For beam coinciding with wall around plant,

M = 432,000#

W = 11880# V = 118800#

$b'd = \frac{118800}{100} = 1188$ let b = 3/4 b and $d = \frac{4\text{x}1188}{3} = 40"$, and b' = 30" $f_c = 650$ jd = 36.

A = 9.6 sq. in. and 9 – 11/8" rods spaced 31/2" will be used.

A 7/8" stirrup will be used.

For compression 3 rods will be turned up.

Columns.

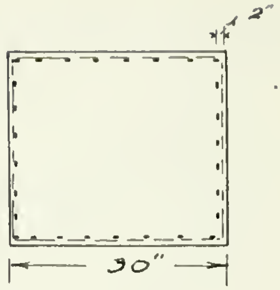
For maximum condition of loading

$P = 4x69000 + 4x48600 = 470,000\#$

From formula $P = f_c A \{1 + (n - 1)p$

where f_c is assumed as 600#

$n = 15$ and $P = .015$ we have,



$A = \frac{470,000}{726} = 650$ sq. in. or call it 30"x30" square column. This allowes 2" each side of steel.

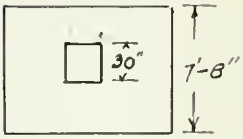
Area steel $= .015x650 = 9.75$ sq. in.

Will use 28 – 5/8" rods spaced 4".

Footings:——

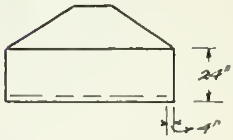
$P = pl^2$ where p = allowable bearing pressure on soil, say 8000# and

P = column load.



$l = P/p = \frac{470,000}{8000} = 7.67'$ or 7'– 8".

$M = Rbd^2 \quad V = vld \quad U = \frac{V}{\Sigma_o jd} \quad M = f_s ajd$



$b = a + 2d + \frac{1}{2}(l - a - 2d)$.

$f_c = 500\# \quad f_s = 14000\# \quad V = 40$ diag. tension

75 punching shear $U = 115$

$A = 2.5'$

From punching shear $V_p = \frac{1}{4}(l^2 - a^2)p$ we get $V_p = 105,600\#$

Therefore, $d = V_p/v_{pa} = \frac{105600}{75x60} = 22"$ or total of 24"

$b = 30" + 44 + \frac{1}{2}(18) = 84"$ or 7'– 0".

$M = \frac{1}{4}(58.8 - 2.6)\, 8000x12 = 1,348,800"\#$ call $R = 77$.

$bd^2 = M/R = \frac{1,348800}{77} = 17510$

$d = \frac{17510}{84} = 15"$ which is lower than above, hence O.K.

For diagonal tension.

$Vd\ 4(a+2d) = p\ (l^2 - (a+2d)^2)$

$V = \frac{8000\ (59.8 - 38.44)}{45.9} = 3550\#$ per sq. ft.

or 25# per sq. in. and O.K.

$M = f_s ajd$ or $A = \frac{1,348,800}{14000 x .87 x 22} = 5.1$ sq. in.

Will use 15 - 5/8 in. square rods spaced 6" along 84".

Solid footing: —

Maximum load per lineal foot of wall = 9x1320 + 32

x1x2x150 = 21780#

Load in lbs. per sq. in. = $\frac{21780}{12x20} = 91\#$

Allowable pressure of soil = $\frac{8000}{144} = 56\#$ per sq. in.

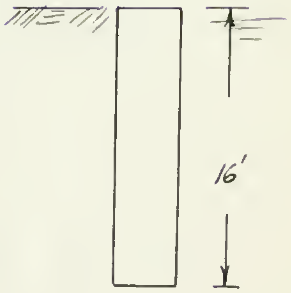
Therefore, area of footing = 91/56x240 or 398 sq.in.

or 12"x2'- 11" which means that footing is 3"- 0"

wide per running foot of wall.

Walls.

For clear water basin.



Water pressure = 62.5x16 = 1000#

Earth " = 25x16 = 400#

Difference = 600#. $M = 1/10\ wl^2$

$= \frac{600}{10} x400 = 24,000'\#$ or 288,000"#

$d = \frac{24,000}{71} = 18"$ call it 20" total.

$a = pbd = .0075x12x18.5 = 1.67$ sq. in.

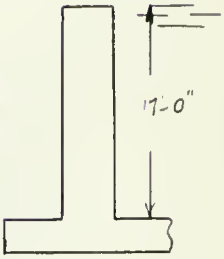
Will use $\frac{3}{4}$" square rods spaced 4".

At 12' point water pressure = 62.5x12 = 750#.
" " " earth " = 25x12 = 300#

Diff.= 450# or h = 15" total.

On account of water pressure existing in settling basin and filter beds above, a 20" wall will be used throughout.

At 12' point a = pbd = .0075x12x13.5 = 1.21 sq. in., or $\frac{3}{4}$" rods spaced $5\frac{1}{2}$". At 8' point rods spaced 8" and run to top of basin.



For settling basin:——

Wall will be figured as a cantilever beam.

Pressure on bottom = 62.5x15 = 940#

Total pressure = $\frac{940}{2}$ x15 = 7050#

M about footing = 7050x15/3 = 35.250'#

M = Rbd^2 Therefore, d = $\frac{35,250}{98}$ = 18" or say 20" total.

A = pbd = .0075x12x19 = 1.91 sq. in. or will use 7/8" rods spaced 4" for 5' from floor.

At 12' down from roof pressure = 10x62.5 = 625#

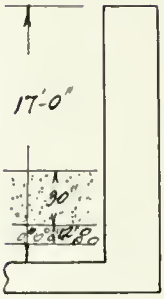
Total = 3125# M = 10415#

d = $\frac{10415}{98}$ = 12" total 14".

Wall will be made 20" thick at floor and sloped up from outside to 12" thick at roof.

A = pbd = 1.14 sq. in. or will use 7/8" rods spaced 8",

which means running through every other rod from below. At 7' from roof rods will be spaced 12" or every third rod run through from bottom 5' section. To take care of shear a 2' fillet was placed between wall and footing, on the outside.



Wall in filter house: ——

Wall to be figured both as a cantilever and a simple beam.

As simple beam pressure at bottom

$= \frac{625 + 1025\text{x}4}{2\text{x}3} = 1100\#$ per sq. ft.

$M = 1/10\ wl^2 = \frac{1100\text{x}324}{10} = 35,640''\#$

$A = \frac{35640}{71} = 22''$ or say 24".

This will necessitate a 6" fullet on bottom.

$a = pbd = .0075\text{x}12\text{x}22 = 1.98$ sq. in.

Will use $\frac{3}{4}$" rods spaced $3\frac{1}{2}$".

At topof sand bed water press. = 625# per sq. ft.

$M = 1/10\ wl^2 = 20,250'\#$

d = 16" but will make a 20" wall all the way for steel is to be placed on both sides.

$a = pbd = .0075\text{x}12\text{x}16 = 1.50$ sq. in., or $\frac{3}{4}$" rods spaced $4\frac{1}{2}$".

At 7' down water pressure = 313# per sq. ft.

$M = 10,140'\#$ $d = \frac{10140}{71} = 12''$.

A = pbd = 1.08 sq. in. or $\frac{3}{4}$" rods spaced 6" and run to top.

As a cantilever $\frac{3}{4}$" rods spaced every 12" will be run throughout whole wall. Walls of other basins and rooms along plant will be reinforced as seen necessary.

WAUKEGAN, ILL.

SPECIFICATIONS
for the
CONSTRUCTION OF A MECHANICAL FILTRATION
PLANT AND APPURTENANCES.

GENERAL CHARACTER AND DESCRIPTION OF THE WORK.

Location of the Work.

1. The work to be done comprises the construction of a mechanical filtration plant in complete working order with a nominal daily capacity of six million gallons and all appurtenances, on Harbor Place near Madison St.

Extent of Contract.

2. The work includes the construction complete of the following structures:

(a) A settling basin about 75 feet by 50 feet in size and 15 deep, divided into two compartments and having a total capacity of approximately 450,000 gallons, giving a nominal period of sedimentation of two hours. This basin is to be constructed entirely of reinforced concrete.

(b) A covered filtered-water reservoir about 130x50 feet in size and 15 feet deep, with a capacity of approximately 800,000 gallons. This basin will be constructed entirely of reinforced concrete and will be beneath and form a support for the filters and head house.

(c) A rear structure 35x25 feet in size by 22 feet deep to be divided into an equalizing chamber 35'x10'x 22'deep, a pump room 35x15 by 10' deep and a chemical room for the storing of alum, 35x15x12'deep. This is all to be constructed of reinforced concrete.

(d) A mixing chamber 20x25 in size by 17' deep provided with baffle walls throughout. This is to be entirely of reinforced concrete.

(e) Seven mechanical filter units, complete with all appurtenances, each 18x20 feet inside and having an aggregate filter surface of2160 square feet. The filters will be grouped on both sides of a pipe gallery over which is to be an operating platform. All filter tanks, floors and roofs will be of reinforced concrete.

(f) A one story head house of reinforced concrete and brick construction, with tile roof supported on

steel trusses and a wing of similar construction over the operating platform. The inside dimensions of the head house will be about 20 by 50 feet and of the wing about 22 by 60 feet. The head house will contain tanks and apparatus for the preparation and application of coagulating and sterilizing chemicals, pumps and other machinery for washing the filters, a laboratory, office, toilet rooms and storage space for chemicals, and the low-lift pumping machinery.

(g) Low-lift pumping machinery comprising two three million gallon and one five million gallon centrifugal pumps driven by electric motors for delivering the raw water from the existing intake to the coagulating basin.

(h) Necessary piping connections consisting of various cast-iron pipe lines and vitrified pipe drains.

Drawings.

(3) The location of the work, together with the details for the construction of the coagulating basin, filtered-water reservoir, filters, pipe gallery, head house, coagulating devices, low-lift pumping equipment, and other appurtenances are shown upon a set of 4 drawings. These drawings, which form a part of the Contract and Specifications, have titles as follows:

1. Location and Plan.
2. ELEVATIONS.
3. Plan and Sections of Mixing Chamber, Settling Basin, Rear Structure and Clear Water Basin.
4. Plan ~~or~~ and Sections of Filter and Head house.

Where figures are given on the drawings they shall take precedence over dimensions by scale. Such additional drawings as are necessary to make clear the intent of these specifications will be furnished from time to time during the progress of the work by the Engineer. Those working drawings herein specified to be submitted by the Contractor for various parts of the work shall be furnished by the Contractor for approval and after approval all work shall conform thereto. These working drawings required by the specifications to be furnished by the Contractor shall be furnished within three months after the date of commencement of the contract.

Laws and Regulations.

(4) The Contractor shall keep himself fully informed of all existing and future Town or City ordinances and regulations, state and national laws in any manner affecting the work herein specified, and he shall at all times observe and comply with and cause all his agents and

employees to observe and comply with said ordinances, laws and regulations, and shall protect and indemnify the City of Waukeegan and its officers and agents against any claim or liability arising from or based on the violation of any such laws, ordinances or regulations. The Contractor shall take out, at his own expense, all necessary permits from the County, City, or other public authorities; shall give all notices required by law or ordinances; shall pay all fees and charges incident to the due and lawful prosecution of the work covered by this contract, and shall comply with all local and state laws and regulations.

Commencement and Time of Doing Work.

(5) The Contractor shall commence work within ten days after the execution of the contract, and the rate of progress shall be such that the whole work shall be performed and the ground cleared up in accordance with the contract and specifications on or before —— unless an extension of this time be made as provided below. If the Contractor is delayed in the prosecution or completion of the work by the neglect, delay or default of any other contractor of the City of Waukeegan, by serious damage to the work from the unusual action

of the elements, by the abandonment of the work by the employees in a general strike, or by delay on the part of the City of Waukeegan in doing work or furnishing materials or rights of way to be done or furnished by it, the Contractor shall have no claim for damages for any such cause of delay, but he shall be entitled to such extension of the time for the completion of the work as the Engineer shall certify in writing to be reasonable, provided, however, that claim for such extension of time is made by the Contractor in writing to the Engineer within a week from the time when any such alleged cause for delay occurs.

Extra Work.

(6) The Contractor shall do any work and furnish any material not herein provided for but necessary for the proper completion of the work or its purposes in the opinion of the Engineer. All extra work shall be ordered in writing by the Engineer, and in no case will any such work in excess of that shown by the original contract plans be paid for unless so ordered. The Contractor further agrees that he shall receive, in full compensation for such extra work, the unit price bid, in the case of items covered by unit prices in the Proposal,

and no more, and for such items as are not covered by a unit price he shall receive in full compensation the reasonable cost, as determined by the Engineer, of all necessary labor and materials, plus 15 per cent for superintendence, the use of tools and other overhead expenses. He shall give the Engineer access to all accounts, bills and vouchers relating to extra work in the case of items not covered by unit prices, unless a statement in writing of the actual cost of same, fully itemized as to labor and materials, is presented to the Engineer before the 15th day of the month following that during which each specific order was complied with by him.

Lines and Grades.

(7) All necessary lines and grades will be given promptly bythe Engineer, and the Contractor shall provide at his own expense such materials, labor and assistance as may be required, and shall carefully preserve all marks and grades given. The Contractor shall notify the Engineer in due season whenever he will need lines and grades to other than the ordinary extent; and shall have no redress for delays unless 24 hours' notice in writing is given to the Engineer that more lines and grades will be needed. All work

during its progress and on its completion shall conform to the lines and grades given by the Engineer in accordance with the contract drawings, subject only to such modifications as may be deemed necessary by the Engineer in accordance with the following section.

Sub-Letting.

(8) The Contractor shall give his personal attention constantly to the faithful prosecution of the work. He shall keep the same under his own control and shall not assign, by power of attorney or otherwise, nor sub-let the work or any part thereof without the previous written consent of the Board. He shall also give such information as the Board may require in order to ascertain whether any sub-contractor is responsible, reliable and able to perform the work or furnish materials in accordance with the specifications.

Representative Always Present.

(9) The Contractor, in case of his absence from the work, shall have a competent representative or foreman present, who shall follow without delay all instructions of the Engineer or his assistants in the prosecution and completion of the work, in conformity with this contract, and shall have full authority to supply labor and

material immediately.

Employment of Competent Men.

(10) The Contractor shall employ only competent and skillful men to do the work, and whenever the Engineer shall inform him that any man on the work is, in his opinion, incompetent or disorderly, or uses threatening or abusive language to any official having supervision of the work, such man shall be discharged, and shall not again be employed on the work without the consent of the Engineer.

Material and Workmanship.

(11) It is the intent of these specifications to describe definitely and fully the character of materials and workmanship required with regard to all ordinary features, and to require first-class work in all particulars. For any unexpected features arising during the progress of the work and not fully covered herein the specifications shall be interpreted by the Engineer to require first-class work, and such interpretation shall be accepted by the Contractor.

Sanitary Regulations.

(12) Necessary sanitary conveniences for the use of the laborers on the work, properly secluded from observation, shall be erected and maintained by the Contract-

or in such manner and at such points as shall be approved and their use shall be strictly enforced. The contents of the same shall be removed with sufficient frequency to prevent nuisances and disposed of to the satisfaction of the Engineer. The Contractor shall obey and enforce such other sanitary regulations and orders and shall take such precautions against infectious disease as may be deemed necessary. In case any infectious disease occurs among his employees he shall arrange for the immediate removal of the patient from the work and isolation from all persons connected with the work. The building of shanties or other structuresfor housing the men, tools, machinery or supplies will be permitted only at approved places, and the sanitary condition of the grounds in and at such shanties or other structures must at all times be maintained in a satisfactory manner.

Inspection.

(13) All the materials and work necessary or proper for the building and completion of the work herein specified will be inspected by the Engineer or his inspectors, and the Contractor shall furnish him and his inspectors with all needed facilities for discharging the duties assigned to them. When, in the judgement of the inspectors, the work or materials are not in

accordance with the specifications, they shall have the power to stop the work, which shall not be resumed until the Engineer has rendered his decision upon the matter in dispute. The inspection of the work shall not release the Contractor from any of his obligations to fulfill his contract as herein spexified, and defective work shall be made good and unsuitable materials may be rejected, notwithstanding such work and materials may have been previously accepted, for payment.

Boundaries of Work and Contiguous Work.

(14) The Board will provide rights of way for all work specified in this contract, and the Contractor shall not enter or occupy with men, tools or materials, any private ground outside the property of the Board without the consent of the owner. Other contractors of the Board may for all purposes required by their contracts, enter upon the work and premises used by the Contractor, and the Contractor shall give to other contractors of the Board all reasonable facilities and assistance for the completion of adjoining work.

Removal of Temporary Structures.

(15) On or before the completion of the work the Contractor shall, without charge therefor, tear down

and remove all buildings and other structures built by him for facilitating the carrying out of the work, and shall remove all rubbish of all kinds from the grounds which he has occupied, and shall leave the line of work clean and in good condition.

Injury to Existing Structures.

(16) In case any damage **shall result** to any existing pipes for water, steam, or other purposes, or the dam or pumping station or their appurtenances, due to acts of omission or commission on the part of the Contractor, he shall without delay and at his own expense repair the same to the satisfaction of the Engineer, and in case such repairs are not made promptly or satisfactorily the Board may have the repairs made by contract or otherwise and deduct the cost of same from any moneys due or to become due the Contractor.

Patent Rights.

(17) The Contractor shall be responsible for any claims made against the City or any of its agents for any infringement of patents by the use of patented articles in the construction and completion of the work, and shall save harmless and indemnify the City and its agents for all costs, expenses and damages which the City may be obliged to pay by reason of any

infringement of patents used in the construction, completion, or operation of the works herein specified. Prior to the final acceptance of the work done by the Contractor, and as a condition precedent to the payment of any moneys on the final estimate the Contractor shall furnish the Board a bond in the sum of Fifteen Thousand ($15,000.) Dollars, with security satisfactory to the Board, to protect the City and its agents for a period of six years thereafter against any claim for infringement of patents due to any work done or materials or processes used or installed by the Contractor or utilized by the City in the operation of this plant, as herein specified.

ITEM I. — EARTH EXCAVATION.

Extent.

(18) Under Item 1 the Contractor shall make all excavations, except in rock, necessary for the construction of the coagulating mixing chamber, settling basin, pump room basin, filtered-water reservoir, filters, headhouse, connecting piping, and all of their respective appurtenances, carrying the excavations for the various structures to the lines and grades shown on the drawings or given by the engineer.

Clearing and Grubbing.

(19) The site of all excavation shall first be cleared and grubbed of all trees, lumber, walls, stumps, brush, and rubbish, which shall be removed or disposed of in a satisfactory manner. The buildings and telegraph poles now on the site of the work will be removed by the Board. Any top soil taken from places where excavation is to be made shall be placed aside and piled up compactly for subsequent use in surfacing embankments or for grading.

Disposal of Excavated Material.

(20) Excavated material shall be deposited in such a manner as to interfere as little as possible with the execution of the work under this contract or under adjoining contracts. So far asfeasible the excavated material may be placed in its final embankment, but it shall not be done in a manner to interfere with the satisfactory carrying out of the work. Such excavated material as cannot be placed directly in its position as embankment shall be removed to one side to a temporary spoil bank, whence it shall be subsequently taken. Any excavated material not used in embankments or fills shall be graded off in a neat and satisfactory manner.

Removal of Water.

(21) The Contractor shall provide a suitable plant with which to remove and properly dispose of all water promptly from all excavations and keep them dry until the structures to be built therein are completed and the concrete or mortar is sufficiently set to allow water to come upon it.

Shoring.

(22) In trenches and other excavations where sheet piling, shoring, bracing, or other supports are necessary, they shall be satisfactorily furnished, placed and maintained by the Contractor.

Embankments.

(23) Embankments shall be built of the materials removed from the excavation, so far as possible, arranging them in the most suitable manner and compacting them with a suitable roller. When filling or refilling excavations for foundations under structures, the compacting shall be done thoroughly in 4-inch layers and all backfilling around masonry structures shall be thoroughly rammed. The embankments about the walls of the chambers and basins shall be made as the work progresses, in order to facilitate the convenience of doing other work and guarding the masonry structures

against accident.

Measurement.

(24) All earthwork will be measured in excavation, and will be measured only once. Excavations for masonry structures will be measured between vertical planes passing through the outside of the structures and from the surface of the ground to the neat lines of the bottoms of the structures, or to such greater depths as the Engineer may order. Excavations for pipe lines shall be measured between vertical planes 2 feet farther apart than the inside diameter of the barrel of the pipe, and from the surface of the ground to the elevation of the invert of the pipe. No allowance shall be made for bell holes, gates, or other purposes. All other excavation will be measured within the lines and grades actually given.

Compensation.

(25) The price bid per cubic yard under item 1 for Excavation includes all labor, materials, and appliances for excavation of all kinds except rock, and for the disposition of the materials excavated, whether they are placed directly in embankments or otherwise disposed of, and for grading the surface to the given lines and grades, including the dressing of the surface

with loam and seeding the same, and all pumping, shoring, and other expense incident to the work of earth excavation and embankment.

ITEM 2. — COAGULATING BASIN, MIXING CHAMBERS, SETTLING BASIN, FILTRATION PLANT, AND FILTERED-WATER BASIN.

Work Included.

(26) Under Item 2 the Contractor shall furnish all materials (except steel reinforcement) for and construct complete a coagulating basin, mixing chambers, settling basin, filtration plant and filtered-water reservoir, as shown on the drawings and specified in detail under the following sections of these specifications:

A. Concrete
B. Steel Reinforcement (Item 4).
C. Equalizing Basin.
D. Mixing chambers.
E. Settling basin.
F. Filtered-Watered Reservoir.
G. Filter Tanks and Concrete Portion of Headhouse.
H. Filter Equipment.
I. Connecting Piping.
J. Chemical Apparatus.
K. Filter Building Superstructures.
L. Pumping Equipment.

A.—CONCRETE.

(27) All concrete used in the construction of the various structures under Item 2 shall be made and placed in accordance with the following general specifications, supplemented by the specifications given under other headings:

Proportions.

(28) Concrete shall be composed of substantially one volume of cement, two volumes of sand, and four volumes of gravel or broken stone, unless a leaner mixture is allowed by the Engineer for some specific purpose. The sand and gravel or broken stone shall be so graded in size that the cement shall more than fill the voids in the sand, and the sand and cement shall more than fill the voids in the broken stone or gravel. One bag of cement weighing at least 93 pounds net shall be regarded as having a volume of one cubic foot, and the sand and gravel shall be measured loose.

Portland Cement.

(29) Cement shall be first-class Portland cement of a reputable brand satisfactory to the Engineer. It shall be stored in weather-proof buildings having

wooden floors raised above the ground, and sufficient stock shall be kept on hand to allow ample time for testing. All necessary facilities shall be provided by the Contractor to permit of the inspection of the individual shipments, each of which shall be kept separate. All unsatisfactory cement shall be promptly removed from the work. The cement shall conform to the standard specifications of the American Society for Testing Materials, and tests will be made in general accordance thereto, with limits as follows:

Specific Gravity. Not less than 3.1.

Fineness. 92 per cent. passing 100 sieve, 75 per cent. passing 200 sieve.

Time of Setting. Initial set in not less than one hour; final set between three and ten hours.

Tensile Strength. In pounds per square inch.

Age.	Neat Cement.	1 Cement, 2 Sand
24 hours	175	...
7 days	500	200
28 "	600	275

Soundness. Pats satisfactory for 28 days in air and also one day in air and 27 days in cool water; also in steam for 5 hours after hard set.

Sand.

(30) Sand for concrete and mortar shall be a clean

coarse silica sand which will pass a screen having four meshes to the lineal inch. It shall not contain over 5 per cent. of clay or other very fine material, and shall be practically free from organic matter. The size of sand grains shall be graduated rather than uniform. Crushed stone or gravel screenings may be used as sand for concrete, where satisfactory to the Engineer.

Crushed Stone or Gravel.

(31) Crushed stone or gravel shall consist of clean, hard, durable particles of stone, well graded between the limits of ¼ and 1½ inches, with all dust and all particles less than ¼ inch removed. It shall be free from loam, clay, organic matter, soft or micaceous pebbles or other impurities. When directed for thin sections of concrete a finer stone than specified above shall be used, and for very heavy sections a somewhat coarser stone will be permitted.

Water.

(32) Water for mortar and concrete and for all other purposes shall be provided by and at the expense of the Contractor, and shall be free from oil, acid, strong alkalies or vegetable matter.

Forms.

(33) The Contractor at his own expense shall provide

suitable centers or forms with smooth surfaces of ample strength and rigidly braced. The bracing shall be entirely adequate to prevent any deviations from the correct lines. No center or form shall be used which is not clean and of proper shape and strength and in every way suitable. Deformed, broken or defective centers or forms shall be removed from the work. All forms shall be watertight, and wetted before using.

Mixing.

(34) The concrete shall be mixed by an approved machine with arrangements such as will secure a suitable mixing of each batch of concrete. These arrangements shall provide for the correct measurement of each of the ingredients before placing in the mixer, the mixing of the ingredients dry and the introduction of a measured quantity of water at any stage of the process. The mixing shall be continued until every particle of ballast is completely covered with mortar. No concrete will be allowed to be put in place after its initial set has taken place, and no retempered concrete will be allowed to be used under any conditions. The mixtures shall be moderately wet, and no excessively wet nor very dry concrete will be permitted.

Placing of Concrete.

(35) After mixing, the concrete shall be transported as rapidly as possible and deposited in place. It shall be carried up level along the whole length of the section under construction, and shall be so placed as to avoid rehandling within the forms. It shall be joggled or rammed into place by light rammihg. No concrate shall be deposited under water, and water shall not be allowed to rise or flow over the masonry until the cement has properly set. Special care shall be taken to see that the concrete is placed solidly against the forms, so as to leave no voids, and to this end the Contractor shall use a suitable tool, in order to remove any air entrained within the concrete and to force the ballast away from the forms, thus leaving a layer of mortar next thereto.

Joints and Bonding.

(36) At joints the concrete last to be laid shall be suitably grooved, and upon resuming operations the exposed surfaces shall be thoroughly cleaned and wetted so as to give a satisfactory bond with the new concrete. The work shall be so arranged that joints will be left only at such places as will not, in the opinion of the Engineer, be detrimental to the strength

watertightness or appearance of the structures.

Finished Surfaces.

(37) All concrete floors and the tops of all walls and exposed surfaces of other structures shall be finished with a satisfactory coating of rich mortar and well floated. All floors of buildings and outside walks and platforms shall have hard, troweled, granolithic surfaces.

Pipe in Walls.

(38) Pipes or castings as shown on the drawings or as directed shall be placed by the Contractor in the concrete. Special care shall be taken to place them at the proper lines and grades and to tamp thoroughly around them so that there shall be no passage for water around them.

Care of New Work.

(39) All exposed surfaces in finished and unfinished concrete shall be kept constantly moist by sprinkling with water at short intervals or by covering with moistened burlap or by such other means as may be approved until the permanent covering is in place or until, in the opinion of the Engineer, the concrete is sufficiently hardened. No new work shall be laid during rain-storms, and freshly laid concrete

shall be protected by canvas during storms to prevent the water from coming in contact with it. Sufficient canvas covering shall be provided and kept ready at hand for this purpose.

B.— STEEL REINFORCEMENT.

Work Included.

(40) All steel reinforcement used in the several portions of this work shall be of the quality stated in, and placed in accordance with, the following general specifications, supplemented by the special specifications given under other headings.

Quality.

(41) Bars or rods shall be of mild steel with an ultimate tensile strength of from 55,000 to 65,000 pounds per square inch and an elastic limit of not less than 27,000 pounds per square inch, and shall be twisted or deformed in an approved manner. Test specimens shall bend cold 180 degrees flat without fracture. Expanded metal shall be of a pattern and quality satisfactory to the Engineer. All reinforcement shall be clean and reasonably free from rust when placed in the concrete.

Placing.

(42) All bars or other steel reinforcement shall be

placed accurately in position, as shown on the drawings or as directed. The bars shall be bent accurately to the form shown, and wherever required bent at the ends. All reinforcement shall be securely held in place in a satisfactory manner, and bars shall be wired together at intersections as often as necessary. Adjoining bars at splices shall overlap at least 40 diameters and steel rod clamps shall be provided and placed where shown on the drawing or as ordered.

C. — EQUALIZING BASIN.

Work Included.

(43) Under Item 2 the Contractor shall furnish all material and construct complete the coagulating basin of about 55,000 gallons capacity, as shown on the drawings. The excavation and steel reinforcement will be paid for under Items 1, and 4.

Joints and Bonding.

(44) The walls and floor of the basin shall be built in monolithic sections, with joints only at such points as are shown on the drawings or directed by the Engineer. Joints shall be as few as possible, and special care shall be used to make them watertight by means of suitable grooves, which shall be carefully cleaned and painted with neat cement grout before the next section is placed.

Watertightness.

(45) All cracks or imperfections developing at anyppoint in the structure shall be thoroughly repaired in a perfectly satisfactory manner. At the close of the work each compartment of the basin shall be filled with water, and the Contractor shall repair any imperfections which cause the water level to fall more than one inch in 24 hours. All noticeable leaks in any portion of the basin shall be repaired in any case, even if the basin satisfies the preceding requirement as to watertightness.

D.— MIXING CHAMBERS.

Work Included.

(46) Under Item 2 the Contractor shall furnish all material and construct complete the mixing chambers as shown on the drawing, including the baffle partitions. The Excavation and steel reinforcement will be paid for under Items 1 and 4.

Baffles:-

The baffle walls shall be constructed as shown on drawing, and be everly plastered on both sides. The plastering shall be done with a mortar consisting of 5 parts of Portland Cement, 12 parts of sand and one part of lime paste. The mortar shall be applied with-

in 30 minutes from the time of mixing.

E.— SETTLING BASIN.

Work Included.

(47) Under item two the Contractor shall furnish all material and construct complete the double settling basin of about 450,000 gallons as shown on the drawing including division wall. The excavation and steel reinforcement will be paid for under items 1 and 4.

Finished surfaces.

The bottom of the basin shall be screeded and troweled to a smooth surface and shall be pitched uniformly to central drains. The top of all walls and floors shall be troweled to a hard, smooth surface.

Joints and Bonding.

The walls and floors shall be built in monolithic sections. Joints shall be as few as possible, especial care should be used to make them watertight.

Watertightness.

All cracks or imperfections developing at any point in the structure shall be thoroughly repaired in a perfectly satisfactory manner. At the close of the work each basin shall be filled and tested for leaks as explained in art.

F. — FILTERED WATER RESERVOIR.

Work Included.

(48) Under Item 2 the Contractor shall also furnish all materials for and construct complete the filtered-water reservoir of 800,000 gallons capacity as shown on the drawings, including sumps for the wash-water and high-lift pump suctions and manholes. Excavation and steel reinforcement will be paid for under Items 1, and 4. All of the filtered-water reservoir lies beneath the filters and headhouse and is constructed entirely of reinforced concrete with columns and piers for the support of the structures above,

Manholes.

(49) The manholes will consist of a concrete cylindrical section, with a suitable frame and cover at the top. The frames and covers shall be made from a good quality of cast-iron of satisfactory pattern and weight and properly coated in a similar manner to that ordinarily employed for cast-iron pipe.

Finished Surfaces.

(50) The floor of the filtered-water reservoir shall be finished with a 4" layer of asphalt. No special finishing of the walls below the final ground

level will be required, except that any porous places shall be properly repaired.

Leakage.

(51) All cracks or imperfections developing in the structure shall be thoroughly repaired in an entirely satisfactory manner, including any leaks which may allow ground water to enter the reservoir from the outside. At the close of the work the filtered-water reservoir shall be filled with water and the Contractor shall repair any imperfections which cause the water level to fall more than one inch in 24 hours.

G. -- FILTER TANKS AND CONCRETE PORTION OF HEADHOUSE.

Work Included.

(52) Under Item 2 the Contractor shall also furnish all materials for and construct complete as shown on the drawings the seven filter tanks, with the operating and pipe gallery floors between them; the ground floor and second floor of the headhouse, the walls of the headhouse and the wing over the operating floor up to the point where the brickwork commences; the four concrete chemical tanks the platform for the lime tanks, and the stairs in the headhouse.

Watertightness of Tanks.

(53) The filter and chemical tanks shall be constructed with as few joints as possible, and great care shall be taken where joints are necessary to make them watertight, and also at all points where pipes or castings pass through the walls or floors of the tanks. At the close of the work all tanks shall be filled with water and the Contractor shall repair any imperfections which cause the water to fall more than ½-inch in 24 hours. All places which show appreciable seepage from any of the tanks on the inside of the filter plant shall be made perfectly tight, even if the tanks fulfill the preceding requirement for tightness.

Finished Surfaces.

(54) The sides of the filter tanks in contact with the sand shall be finished rough by brushing or sanding, so as to make a satisfactory joint between the filtering material and the sides of the tank. All floors, stairs, and tops of walls shall be furnished with a smooth, hard satisfactory granolithic surface which will not "sand." The exposed tops of tank walls, edges of stairs, foundations, and platform shall be finished in a neat manner, with rounded edges. All exposed edges, columns, beams, platforms, or walls,

shall have a satisfactory even beveled edge.

Holes for Piping.

(55) The Contractor shall accurateky lay out all pipe lines before the concrete work under this Item is commenced, and shall provide suitable openings where pipe lines pass through the walls. Care shall be taken to set all wall castings to the exact position required, so as to facilitate the erection of connecting piping under other items.

H. — FILTER EQUIPMENT.

Work Included.

(56) Under Item 2 the Contractor shall also furnish and install complete and ready for successful operation the filter equipment shown on the drawings and specified in detail under the following heads:

Strainer Systems.
Filter Piping.
Hydraulic Valves.
Operating Tables.
Loss of Head Gages.
Wash Water Gages.
Depth Gages.
Filter Gravel.

Filter Sand.

Rate Controllers.

Wash Water Gutters.

Wash Water Pump.

Sampling Devices.

Venturi Meter.

Each bidder shall submit with his bid a statement showing which type of strainer system he will use and indicating how he will modify within the limits specified if at all, the arrangement of the filter piping. He shall also furnish drawings and specifications showing the arrangement of operating tables, loss of head gages, wash water gages, depth gages, and rate controllers. He shall indicate also where these respective devices will be manufactured and where devices of the same make are now in successful use. The Contractor shall furnish complete drawings and specifications for all of these features of the filter equipment in accordance with the terms of Section 3 of these specifications.

Methods of Washing.

(57) The filters will be washed by means of the High Rate Water Wash, which consists in the application of filtered water alone at a rate of 15 gallons per sq. ft. per minute through a strainer system constructed of concrete channels and ridges with perforated brass strain-

er plates.

STRAINER SYSTEM FOR HIGH RATE WATER WASH.

Ridges and Channels.

(58) The strainer system for the High Rate Water Wash is constructed with concrete channels and perforated brass plates, as detailed on Sheet 3 of the drawings. The ridges shall be composed of concrete of a 1-2-4 mixture, which shall be molded in forms, preferably of cast-iron, strong enough to prevent springing or warping. They may be constructed in place directly on the floor of the filter tank, or cast separately and afterwards placed in position. Especial care shall be taken to preserve from injury and keep in true alignment the edges which form the seats for the strainer plates. All surfaces shall be practically smooth and free from voids, and should any voids occur they shall be plastered smooth before placing the strainer plates. All holding-down bolts shall be set accurately in the ridges before the concrete has set.

Strainer Plates.

(59) All strainer plates shall be made of bronze, No. 16 Birmingham wire gage composed of 85 parts of copper, 5 parts of tin, and 10 parts of zinc, and the

holes shall be punched before the plates are bent to the required shape. The strainer plates shall be placed in rows 12 inches apart and shall lap each other at their ends. They shall be fitted closely together, and shall be neatly joined at their ends with red lead, and laid with a joint of rich mortar along their edges. At the end of each row any space between the strainer plates and the concrete ridges shall be completely filled with cement mortar.

Placing.

(60) Twisted steel anchor rods shall be embedded in the bottom of the filter bed while the concrete is still fresh. If the ridges are cast in position the rods shall be set carefully to line. If the ridges are not cast in position, they shall be set in a thin bed of cement mortar composed of one volume of cement and three volumes of sand, and after they have been fitted over the twisted steel anchor rods the tapering holes shall be filled with the mortar. Before and during the setting of the strainer plates all channels shall be thoroughly cleaned from all dirt and mortar projecting into them, and shall be left perfectly smooth and unobstructed. The contractor shall take particular care not to deform or misplace strainer plates for

bolts while working over them, and if any become injured he shall replace them at his own expense. All parts of the strainer system, particularly the channels under the plates and perforations in the plates, shall be kept clean and free from droppings of mortar.

Testing.

(61) After all strainer plates have been set and before any gravel is placed, the strainer system of each filter shall be tested by passing a large volume of water through it under the conditions that hold in washing the filters. In case any plates are loosened or have their perforations clogged, they shall be thoroughly repaired and cleaned. In each filter at least two strainer plates shall be removed, and if any dirt is found lodged in the under passages the the remaining strainer plates shall be removed, the passages cleaned, and the filter afterwards retested.

Wire Screen.

(62) After the gravel has been placed, the Contractor shall cover the entire filter area with a brass wire screen, made of No. 20 Birmingham wire gage, 10 meshes per inch. The wire screens shall be laid in strips 26 inches wide, spanning two valleys and three ridges,

with adjacent strips lapping at the ridges, and in making openings for bolts especial care shall be taken not to cut the wires. A small bent brass strip shall be bolted on the screen along the top of each ridge, as shown, and if necessary in order to secure perfect contact at the points of lapping, adjacent strips shall be laced with brass wire.

Filter piping.

(63) The Contractor shall furnish and place under Item 2, all piping connections for the filters, including the influent, effluent, wash-water, drain and filter to waste connections; the line from the wash water pump through the pipe gallery and the suction line to the wash water pump and the pressure water line through the pipe gallery. The cast-iron main drain line from pipe gallery to the point of discharge into Harbor Place is included in this item, and also a 2-inch soil pipe drain beneath the pipe gallery floor. The arrangement of piping is indicated on the drawings, but some rearrangement will be permitted to faciliate the use of standard gates and specials and on account of different types of controllers. The dimensions of the pipe gallery, however, shall not be changed, and the general scheme of piping

shall be adhered to so as to allow of convenient access to the gallery. The Contractor shall submit detailed plans of any modifications which he desires to make in the filter piping, showing dimensions of valves, filters, and rate controllers, and no work shall be undertaken until approval of modifications is given by the Engineer. All filter piping except the influent and effluent lines shall be of cast-iron of the quality and weight specified under the section on Connecting piping beyond/ The water pressure line through the pipe gallery shall be of standard weight galvanized wrought-iron pipe. All piping shall be securely supported in a satisfactory manner by means of concrete saddles, stirrups, rods, brick piers or wrought-ifon columns, in general as indicated on the drawings.

Hydraulic Valves.

(64) The Contractor shall furnish and install on the influent, effluent, drain, filter to waste, and wash water connection of each filter a flanged gate valve equipped with a suitable cylinder for hydraulic operation. The hydraulic cylinders shall be of brass, or of cast-iron with a seamless brass lining at least 1/8-inch thick forced into place and accurately

centered. They shall be proportioned to operate satisfactorily under a hydrostatic pressure of 50 pounds per square inch, but shall safely withstand and shall not jam the valve under a pressure of 100 pounds per square inch.

Operating Tables.

(65) The Contractor shall furnish and install on the operating floor at the points shown on the drawings an operating table for each of the seven filters, on which shall be mounted the loss of head gages, and the devices for controlling and indicating the operation of the filter valves.

Construction of Tables.

(66) These tables shall be constructed of the best gray Tennessee marble of uniform color, carefully dressed and polished and firmly fastened together with bronze corner braces and bolts. In the front of each table there shall be two paneled doors of clear, quarter-sawed oak, dressed all over and finished with the best hardwood finish, each door being provided with nickel-plated cabinet and catches. The backs of the tables will butt against the curb around top of filters, and may be left open. The tables shall be of adequate size to support and contain all the necessary appratus for

operating the filters.

Operating Levers and Indicators.

(67) Upon the top of each table shall be placed a lever for each filter valve operating a suitable four-way cock below the table. There shall also be placed on the top a suitable moving hand and dial arranged to indicate the position of each filter valve. All exposed fittings on the tables shall be heavily nickel-plated.

Loss of Head Gages.

(68) The Contractor shall furnish and install on each operating table a loss of head gage of satisfactory type, complete with all necessary floats, float tubes, counterweights, cords, pulleys, and other appurtenances. The gage shall be arranged to accurately record the loss of head through the corresponding filter by means of a satisfactory pen upon a chart mounted on a discor drum revolving once in 24 hours a graduated in an approved manner so as to record distinctly losses ranging from 0 to 12 feet, the travel of the pen being at least 5 inches. The float tubes shall be of 8-inch galvanized wrought-iron pipe capped at the lower end and securely supported in a truly vertical position,

as shown on the drawings. Floats shall be seamless, spherical copper floats at least 6 inches in diameter. The connections from the filters and effluent pipes shall be of ¾-inch brass pipe, with a brass nipple through the concrete wall of the filter. Proper provision shall be made to prevent the entrance of wash water or sand into the float tubes.

Wash Water Gages.

(69) The Contractor shall furnish and install at a convenient point on the operating floor a 12-inch nickel-plated pressure gage of Ashton Valve Company make or equal. The gage shall be graduated to read from 0 to 20 pounds pressure per square inch, and shall be connected to the main wash water line. The gage connections shall be of ¼-inch nickel-plated pipe with brass valves placed at the connections to the wash water lines. The gages shall be mounted upon a suitable finished hardwood gage board. After erection each gage shall be carefully compared with a standard gage and adjusted to read accurately.

Depth Gages.

(70) The Contractor shall furnish and install at convenient points on the operating floor two recording gages, for indicating the water level in the settling

basin and filtered water reservoir. These gages shall be of the same general appearance and quality as the loss of head gages and mounted on satisfactory iron columns at a convenient height above the floor. One gage shall be marked "Depth in Settling Basin" and graduated from 0 to 18 feet; the other shall be marked "Depth in Filtered Water Reservoir" and graduated from 0 to 12. Float tubes, floats, pulleys, cord, charts and other appurtenances shall be furnished and installed as specified for loss of head gages. An electric alarm which can be set to indicate high and low water at any two points shall be installed on each gage with a suitable bell, and an extension shall be run from the filtered water gage to the adjoining pumping station and a suitable 8-inch electric gong placed there.

Filter Gravel.

(71) There shall be furnished and placed in the bottom of each filter, above the strainer system, a suitable depth of graded gravel for supporting the sand layer, so that sand particles will not enter the waterways of the strainer system.

Quality.

(72) All gravel shall consist of hard, durable, rounded particles of high specific gravity, and shall

be free from any considerable amount of thin, flat particles. When digested for 24 hours in cold, strong hydrochloric acid at least 95 per cent, shall remain insoluble. All gravel shall be washed and screened free from sand, loam, clay and organic impurities.

Placing.

(73) The gravel for the high rate water wash strainer systems shall be placed in four layers. The bottom one shall be 5 inches thick, composed of pebbles passing through a screen containing one-inch openings and retained on one having 5/8-inch openings. The second layer shall be 4 inches thick, and the pebbles shall pass through a screen having 5/8-inch openings and be retained on one having 3/8-inch openings. The third layer shall be $1\frac{2}{4}$ inches thick and shall contain gravel passing through a screen with 3/8-inch openings and be retained on one having 3/16-inch openings. The top layer shall be $1\frac{1}{4}$-inches thick, and contain gravel passing a screen with 3/16-inch openings and retained on a screen having 10 meshes per lineal inch of No. 20 wire.

Filter Sand.

(74) Filter sand shall be composed of hard, durable grains either sharp or rounded, free from clay, loam,

dust, and organic matter, with not more than one per cent. of flat or micaceous particles. When the sand, crushed and powdered, is digested for 24 hours in strong, warm hydrochloric acid, at least 95 per cent. shall remain insoluble. The sand shall not contain more than 1½ per cent. of calcium and magnesium taken together and calculated as calcium carbonate ($CaCO_3$); and not more than two per cent. shall be lost on ignition of the powdered sand.

Size of Sand.

(75) The sand shall have an effective size of not less than 0.35 nor more than 0.44 of a millimeter and a uniformity co-efficient of not more than 1.65. Not more than two-tenths per cent.shall be finer than two-tenths of a millimeter, not more than one per cent. shall be finer than twenty-five hundreths of a millimeter, and at least ninety per cent. shall be finer than eight-tenths of a millimeter. The diameters of sand grains shall be computed as the diameters of spheres of equal volumes and all percentages calculated by weight.

Placing.

(76) Especial care shall be taken in transporting and placing filter sand to prevent contamination of

any sort, and sand which may have become dirty either before or after placing in the filters shall be washed or removed and replaced by clean sand in a satisfactory manner. All sand contaminated by organic matter shall be rejected. After sand is in place in the filters it shall be washed at least 10 times with the washing devices connected with the filters, and fine sand appearing at the surface shall be removed by scraping. Sufficient sand shall be placed in each filter to secure a layer at least 30 inches in depth after the sand has been washed and scraped, and conforming to the sizes above given.

Rate Controllers.

(77) The Contractor shall furnish and place 7 rate controllers, one on the effluent pipe from each filter, complete with all connections and appurtenances. The controller shall be of the enclosed Venturi type of a make which has been in successful use for at least one year. Demonstrations of successful operations of a full size working model will be accepted in lieu of the preceding requirement. The controllers shall be capable of maintaining constantly any desired rate of flow between the limits of 500,000 and 1,200,000 gallons daily without any pounding or surging and under the usual varying heads resulting in the operation of fil-

ters, and the actual rate of flow shall not vary at any time more than five per cent. from the mean rate for which the controller is set. When water is passing through at maximum rate above-mentioned, the controller shall not require a head greater than 12 in., including friction losses. Each controller shall be provided with plainly readable devices for setting it at any desired rate of flow, and a dial indicating the actual rate of flow which is taking place. These devices shall be neatly mounted above the operating floor, preferably on the operating tables.

Wash-Water Gutters.

(78) The Contractor shall furnish and install in each filter three longitudinal wash-water gutters for removing the dirty water during the washing of the filter. These troughs shall be made of concrete as shown on drawing No. 4. Suitable supports shall be placed under the gutters.

Wash-Water Pump.

(79) The Contractor shall furnish and install complete and ready for operation at the location indicated in the low-lift pump room a centrifugal wash-water pump driven by an electric motor, for supplying water from the filtered-water reservoir for washing the filters. This pump shall have a capacity of 5400 gallons

per minute. This unit shall be capable of discharging the above quantities through a clogged filter when the water level in the filtered-water reservoir is within one foot of the bottom, and proper consideration shall be taken of the friction losses occurring in the piping connections, strainer system, and dirty sand in designing the unit. The pump shall be of the horizontal side suction volute type of the Henry R. Worthington make or equal. Gate valves with hand wheels shall be placed on both the suction and the discharge lines from the pump, and a suitable check valve shall be placed in the lower portion of the suction line.

Sampling Devices.

(80) The Contractor shall furnish, install and connect at a convenient point near the south end of the pipe gallery a set of 12 sample cocks. These shall be ¼-inch brass bibb cocks with lever handles and firmly mounted on a suitable iron support at convenient distances apart and above the floor, They shall be connected by ¼-inch brass piping as follows, except 2 and 3, which shall have ½-inch brass piping:

1.- One to the effluent line of each filter at a point on the filter side of the controller.

2.- One to the raw-water supply main before it reaches settling chamber.

3.- One to the south end of the settling basin.

4.- One to the influent pipe to the filters in pipe gallery.

5.- One to the pressure water piping in head house.

Beneath the cocks shall be placed a suitable concrete trough, which shall be piped to the drain, with proper-sized soil pipe. Each cock shall have placed above it a suitable metal label stating the source to which it is connected.

Venturi Meter.

(81) The Contractor shall furnish and lay in the raw water line of pipe immediately leaving pumps a Venturi meter, of the Builder's Iron Foundry make or equal, designed to measure accurately a range of flow between 1million and 13 million gallons per 24 hours. A combined indicating, recording and registering device shall also be furnished and placed at a convenient point on the operating floor of the head house.

I. — CONNECTING PIPING.

Work Included.

(82) Under Item 2 the Contractor shall also furnish and install complete and ready for operation the various lines of connecting piping scheduled below, including all specials, valves, sluice gates, piping supports, valve stands, concrete around pipe, and other appurtenances, as shown on the drawings and specified in detail beyond, except that the excavation for pipe

lines will be paid for under Item 1.

SCHEDULE OF CONNECTING PIPING.

1. An 18" cast iron raw water line from the existing suction well at the pumping station to the pumps in low-lift pump room including a gate valve near the suction well.

2. An 18" cast-iron raw-water discharge line from the low-lift pump room to the equalizing chamber and including the Venturi meter tube which is described under filter equipment.

3. An 18" cast-iron settled water line from the settling basin to the pipe gallery emptying into the reinforced concrete main.

4. A central drain in each settling basin emptying into sewers.

5. A 2'– 0" reinforced concrete raw water line from south end of settling basin through operating gallery as shown. 12" cast iron laterals take off from it as shown.

6. A 2'– 6" reinforced concrete filtered water line commencing in operating gallery and running to discharge point in filtered water reservoir. 10" cast iron laterals take off from it as shown.

7. A wash water pipe, 12" cast iron, running from pump room, through settling basin and in operating gallery as shown. 12" laterals take off from it as shown.

8. A drain pipe, 12" cast iron, emptying wash water from filters and running to sewer connections. Laterals 10" as shown.

9. Filter to waste pipe, 8" cast iron, running through gallery as shown and emptying into sewer. Laterals same size.

10. A 24" cast iron pipe from clear water basin to suction well of high-lift pump room.

(83) All cast-iron pipe and special castings shall conform to the requirements of the standard specifications of the American Waterworks Association, which are hereby made a part of this contract. Pipes and specials shall be Class A, except for the water pressure line, which shall be Class C. Pipe and specials shall be of hub and spigot type, except where flanged pipe or specials are indicated on the drawings or required in making connections to existing piping. All flanges shall be faced and have standard drilling, and all hubs shall be of ample size to receive the socket of the adjoining pipe or special and leave proper lead space.

Inspection of Cast-Iron Pipe.

(84) An inspector appointed by the Board may, under instructions and directions from the Engineer, inspect

and supervise the work and material at the foundry and see that the stipulations of the specifications are faithfully performed. He shall have unrestricted access to all parts of the works, and tests and weighing shall be made under his personal supervision, whenever so required, and the Contractor shall finish him with proper tools, specimens, appliances and labor necessary for testing and inspection. A final inspection will be made at the time of laying the pipe, whether or not an inspection made at the foundry, and any pipe or casting found defective at that time or before the termination of this contract shall be replaced with a satisfactory pipe or casting at the Contractor's expense.

Coating.

(85) All cast-iron surfaces of valves and sluice gates outside and inside shall be thoroughly cleaned and coated with asphaltum varnish, applied hot, or other approved metal coating. All bronze tool-finished work shall be left bright. Finished cast-iron work shall be coated with tallow.

Shop Test.

(86) All valves shall be built to operate continuously under a working pressure of at least 50 pounds

per square inch, except hose valves and others on water pressure line, which shall be for 150 pounds pressure per square inch. Sluice gates shall be built for a working pressure of 20 pounds against either side. Gate valves and sluice gates shall be tested in the shop under test pressures 50 per cent. greater than the above working pressures and a certificate from the manufacturer that the above tests have been successfully withstood shall be furnished by the Contractor.

Inspection.

(87) The Board may appoint an inspector who shall have unrestricted access to all parts of the works where the valves and sluice gates are made for inspection, supervision and testing, and the Contractor shall furnish him with all facilties, tools, appliances and labor for such work. Any part of the work found to be defective at any time after such inspection, or injured in transit to the place of delivery, or in placing, shall be replaced and made good by the Contractor at his expense.

Trench.

(88) All trench in which pipe and appurtenances are to be laid shall be excavated in open cut from the surface, unless otherwise directed in writing, and in

all cases in such manner and to such depths and widths as will give suitable room for placing structures it is to contain and for bracing and draining, for proper blocking and backfilling under the pipe, and for removing any material which the Engineer may deem not proper for foundations. At joints the trench shall be as much wider and deeper as is necessary.

Lead and Yarn.

(89) Lead for joints shall be soft and malleable; cylinders 2 inches in diameter and 3 inches high shall compress without cracking not less than 50 per cent. under a pressure of 15,000 pounds. Yarn shall be the best quality hempen yarn or jute, closely twisted in one piece for each joint.

Pipe Laying.

(90) Suitable tools and appliances shall be used for the safe and convenient handling and laying of all pipe and specials. Great care shall be taken to prevent the coating from being injured, particularly on the inside of the pipes and specials. All pipes and special castings shall be carefully examined by the Contractor for defects, and no pipe or special casting shall be laid or placed in a line which is known to be defective. If any defective pipe or

special casting should be discovered after being laid, it shall be removed and replaced with a sound pipe or special casting without extra charges to the Board. The pipes shall be cleaned before they are laid and shall be kept clean until they are accepted with the complete work. Whenever a length of pipe requires cutting to fit in the line, it shall be so done as to leave a smooth end at right angles to the axis of the bore. This work must be done by the Contractor to the approval of the Engineer, and be included in the price bid.

Closing Ends.

(91) The open ends of all pipes and special castings shall be plugged or otherwise closed to the approval of the Engineer before leaving the work for the night, and for all holidays or other time of interruption of the work. All pipe ends which would otherwise be left open at the end of the contract shall be provided with suitable wooden caps or plugs.

J.— CHEMICAL APPARATUS.

Work Included.

(92) Under Item 2 the Contractor shall also furnish and install complete and ready for operation a complete equipment for the preparation and application of solutions of coagulating and sterilizing

chemicals, as indicated on the drawings and specified in detail under the following heads:

- Solution Tanks.
- Stirring Devices.
- Chemical Feeding Devices.
- Solution Pumps.
- Chemical Piping.
- Weighing Scales.
- Solution Tank Gages.
- Strainers and Screens.
- Points of Discharge of Chemicals.
- Hypochlorite of Lime Mixing Box.

Solution Tanks.

(93) There will be 4 solution tanks as follows: Two rectangular concrete tanks, each with a capacity of 2,000 gallons, for sulphate of alumina; and two rectangular concrete tanks, each with a capacity of 2,000 gallons, for hypochlorite of lime. The sulphate of alumina and hypochlorite of lime tanks will be constructed of concrete as shown on the drawings and specified herein under sections on concrete and steel reinforcement. Cast-iron manhole frames and covers will be placed in the top to allow access to the tanks, and small foundattion blocks shall be built tu support the

agitating devices. In the top of the sulphate of alumina tanks a concrete trough shall be constructed with a copper screen bottom for dissolving chemicals.

Stirring Devices.

(94) Suitable devices shall be installed in each solution tank for stirring and mixing the contents of the tank by means of power. Each agitator shall consist of a vertical shaft with paddles revolving horizontally and operated by a bevel gear and pulley at the top and with a bearing at the bottom of the tank.

Chemical Feeding Devices.

(95) There shall be installed, adjusted, and calibrated, 4 chemical feed tanks with adjustable orifices. The tanks shall be of cast-iron of suitable size, with their interior coated with a white enamel finish similar to that commonly used for plumbing fixtures. Each tank shall be provided with an approved durable balanced float valve with a 6-inch hard rubber or glass float, which shall be arranged to accurately control the level of solution in the tank at a fixed height. The feed tanks shall be erected at a point sufficiently above the floor of the gallery so as to discharge chemical solutions by gravity to the various points

designated beyond. The tanks shall be supported on a rigid framework constructed of one-inch galvanized-iron pipe and fittings. The adjustable orifices shall be constructed of hard rubber, heavy enough to retain its shape without warping or leaking. The edges of the orifices shall be sharp, beveled, and accurately cut. The size of the orifices shall be variable between 0 and ½ square inch. Solid funnels or other receptacles which will prevent spattering shall be provided to receive the discharge from the feed orifices. The funnels for alum and hypochlorite shall be of cast brass; those for lime; of iron.

Solution Pumps.

(96) Duplicate horizontal centrifugal volute pumps shall be provided for raising each of the solutions to the proper orifice boxes. Each pump shall have a capacity of at least 15 gallons per minute against the maximum lift under which they will work, and the suction and discharge openings shall be at least ¾ inch in diameter. The pumps may be either of the side or double suction type, and shall run at a speed not to exceed 1,200 revolutions per minute. All parts of the pumps exposed to alum or hypochlorite of lime solutions shall be constructed of acid-proof bronze, but the lime

pumps shall be of iron.

Chemical Piping.

(97) All piping connecting the several devices shall be provided in duplicate with valves and cross connections so that any combination of the several devices for each solution may be used and any device or length of pipe cut out of use for inspection or repair without interrupting the application of any chemical. The plant shall be laid out so that the lines of pipe, especially the lime piping, shall be as short as possible. Piping subject to action of the chemicals shall be of material not acted upon by the respective chemical solution that it is to contain. The lines from the feed orifices to coagulating basins and the drains from solution tanks may be of extra heavy Cast-iron soil pipe. Water pressure lines shall be of galvanized wrought-iron pipe and steam lines of black wrought-iron pipe. A $\frac{3}{4}$-inch connection shall be run from the pressure water line to each chemical funnel and each solution pump, with necessary valves to permit of flushing chemical feed lines.

Suitable galvanized-iron perforated spray pipes shall be placed over the dissolving troughs of the sulphate of alumina tanks and all necessary supply and waste connections shall be made to the lime slaking box and

hypochlorite of lime mixing box.

All mixing boxes and solution tanks shall have drain connections of liberal size, with proper valves. These drains shall be connected to a main drain discharging into Harbor Place.

Weighing Scales.

(98) There shall be furnished and installed in the coagulant mixing room a set of Fairbanks No. 1,068 floor scales, or equal, set dormant in the floor, at a point to be located by the Engineer, a full set of weights being furnished with the scales.

Solution Tank Gages.

(99) There shall be provided in connection with each of the 4 solution tanks a recording gage. Float tubes shall be placed in or adjacent to the solution tanks, and shall be made of material which will effectually resist the action of the solution which they are to contain. The floats shall be made of hard rubber or glass. The recording devices shall be suitably mounted at a convenient point near the operating floor, and the wires connecting them with the floats shall pass over small brass pulleys.

Strainers.

(100) On the end of the outlet or suction pipe from each alum and hypochlorite solution tank a hard rubber

pipe strainer shall be provided, 2 feet long, drilled with sufficient 1/16-inch diameter holes to equal an area 100 per cent in excess of the area of the pipe. For the lime solution tanks such other provision of readily-cleaned screens shall be made as will prevent the passage of particles which will clog the orifices.

Points of Discharge of Chemicals.

(101) The piping for hypochlorite of lime shall discharge in a satisfactory manner into the filtered water before the main connects with the basin. The sulphate of alumina piping shall connect with raw water at point where water flows over weir of equalizing chamber.

Hypochlorite of Lime Mixing Box.

(102) There shall be installed near the corresponding solution tanks a hypochlorite of lime mixing box of the type manufactured by the New York Continental Jewell Filtration Co., or some equally satisfactory device. This device shall be adapted to dissolving bleach with the aid of mechanical agitation and shall be operated by a belt, pulleys and clutch from the jack-shaft driving the chemical agitators. All necessary connections to the drain, hypochlorite of lime solution tanks, and

the pressure water piping shall be properly made.

Drawings.

(103) The Contractor shall furnish for approval detail drawings of all chemical apparatus which he proposes to furnish, showing the size and arrangement of all piping and valves and the nature, quality and method of construction of all portions of the apparatus. Such drawings shall be modified, if necessary, to make them satisfactory to the Engineer, and after approval by him all work shall conform strictly thereto.

K. — FILTER BUILDING SUPERSTRUCTURE.

Work Included.

(104) Under Item 2 the Contractor shall also furnish all materials for and construct complete the brick superstructure of the headhouse and the wing over the operating platform, as shown on the drawings and specified in detail under the following heads:

Brick Masonry.
Mortar.
Sills and Lintels.
Skylight.
Doors and Door Frames.
Window Frames and Sash.

Interior Finish.

Plastering and Partitions.

Lighting.

Railings.

Plumbing.

Heating.

Brick Masonry.

(105) All bricks shall be sound, hard, well-burned throughout, of uniform size and color, with straight unchipped edges. A good quality of paving brick of satisfactory color shall be used for exterior surfaces and for all interior surfaces which are not plastered. The paving brick shall be equal to samples on exhibition in office of the Board. Before laying all brick shall be thoroughly wet. Bricks shall be laid in full beds of mortar with end and side joints filled at one operation. The best of the bricks shall be selected for the face. Joints of paving brick shall not exceed $\frac{1}{4}$-inch in thickness and shall be struck with a concave tool as the work progresses. Pressed brick shall be laid in Flemish bond or with secret patent bond, as required. All courses shall be laid to a libe front and rear and be level, true, straight and plumb. Courses shall corre-

spond with sills, lintels, cornices, etc., without splitting. Brick work shall be suitably protected from the weather during construction. Suitable bearings stones shall be built into the walls to receive the ends of the roof trusses. After completion all interior and exterior surfaces of brick walls shall be cleaned down with a suitable solution of acid. -

Mortar.

(106) All brick masonry shall be laid in a mortar composed of one volume of Portland cement, one volume of slaked lime and four volumes of sand thoroughly mixed together with sufficient water to give a proper plastic consistency. Portland cement shall conform to the requirements specified under Concrete. Sand shall be clean, coarse and sharp, and if necessary shall be screened to remove large particles. Lime shall be first quality wood-burned stone lime and shall be thoroughly slaked before use. Mortar used in exposed faces shall be stained properly to match the color of the brick.

Sills and Lintels.

(107) Sills and lintels for doors and windows, belt courses and name-plate and exterior steps shall be of a durable, hard stone such as sandstone. All sills shall be bedded at the ends only and afterwards carefully

pointed up. The front faces and the tops of sills and the under side of lintels shall be square drove work or finish equal thereto. All beds and joints shall be fair, true and out of wind and worked so as to secure ¼-inch joints.

Skylight.

(108) A skylight of glass tile supported on small tee irons shall be constructed on the roof of the headhouse over the chemical feed devices of size indicated on the drawings and having the same appearance as the balance of the roof as nearly as possible.

Doors and Frames.

(109) All exterior doors shall be of the sizes indicated on the drawings and of Michigan stock pine or cypress 2¼ inches thick. Interior doors shall be 2 feet 9 inches by 7 feet 0 inches in size of yellow pine or cypress 1¾ inches in thickness. All doors shall be paneled and molded, the upper panels being glazed with a single light of plain or ground glass, where required. The stiles and rails shall be mortised, tenoned and securely wedged and glued. Meeting stiles of double doors shall be beveled and the beaded stops securely fastened in place. All door frames shall be rebated to full thickness of the door, exterior frames being

1 7/8 inches and interior frames 1 3/8 inches thick. Exterior frames shall be of clear white pine or cypress and interior frames of clear yellow pine. Brick molds shall be provided. Frames shall be set plumb and well braced, exterior frames being secured to the brick work or concrete with 3 anchor bolts on each jamb, and interior frames nailed to the studding in wooden partitions. Satisfactory thresholds of yellow pine shall be furnished for all interior doors. Thresholds or sills of cut stone shall be provided for all exterior doors.

Window Frames and Sash.

(110) All windows shall be of sizes indicated on the drawings and shall have box frames and double hung sash. The boxes, sills, yokes, outside head and brick mold shall be of clear white pine or cypress, the yokes and sills being 1½ inches and the boxes 7/8 of an inch in thickness. The pulley stiles, parting strips and stop beads shall be of the best quality long leaf yellow pine, the stiles being 1 1/8 inches in thickness. Parting strips and pockets in pulley stiles shall be secured with countersunk brass screws and wood or metal pendulums shall be hung to separate the weights. Frames shall be set plumb and well braced, and each frame shall be

secured to the brickwork or concrete by two heavy iron anchors in each side. All window sash shall be 1¾ inches thick, of clear white pine or cypress, mortised, tenoned and pinned in first-class manner and with meeting rails beveled. Each sash shall be divided into two lights, except where otherwise shown on drawings.

Interior Finish.

(111) All interior finish shall be of first quality long leaf yellow pine or cypress, free from knots or sap, thoroughly seasoned and kiln-dried. Doors and windows shall have 5-inch molded casings of satisfactory pattern, 7/8 inch thick and matched corners. Windows shall have 1 1/8 inch molded stools and 4-inch molded aprons. In the laboratories and office and wherever walls are plastered an 8-inch molded bass shall be placed, and door casings shall be provided with 10-inch plain plinths.

Plastering and Partitions.

(112) The interior partitions around the laboratories, office, chemical mixing and storage rooms and the toilet rooms, and the ceilings of the laboratories, office and toilet rooms and also the wall at the south end of the pipe gallery, shall be constructed of sound strong 2 by 4-inch studs spaced about 16 inches on centers and

securely supported. The partitions in the toilet rooms shall be similarly constructed with 2 by 2 inch studs. Both sides of all partitions and the under side of the ceilings shall be covered with satisfactory metal lathoor expanded metal, securely nailed to the studs. The ceilings of the laboratory and toilet room and both sides of all interior partitions, except in the shower bath, the inside of the wall at the end of the pipe gallery, and the under side of the entire roof, shall be plastered and finished with two good coats of improved hard wall plaster of "Adamant" or other brand satisfactory to the Engineer.

Electric Lighting.

(113) A complete electric lighting system shall be furnished and installed for all portions of the filtration plant. Wiring shall be run in suitable loricated tubing, neatly and securely supported and where possible placed in concrete floors or walls or otherwise concealed. All necessary outlet boxes and cabinets shall be furnished and properly placed, and the lighting wires shall be split into at least five separate circuits, as directed. Lamps shall be arranged in chandeliers, clusters, or brackets, so as to produce the best lighting effect in the neatest manner, and their arrangement shall be satisfactory in every

respect. There shall be the equivalent of one 16-candle power light for each 100 square feet of floor surface. A suitable submerged waterproof light shall be installed in each filter. The current for the lighting will be taken from the same source as the present pumping station lights. A suitable lighting panel shall be furnished with a watt meter and the necessary fuses, switches, and other appurtenances, and installedin the head house to provide for the filtration plant lighting circuits. All electrical work shall conform to the requirements of the National Board of Fire Underwriters. The Contractor shall furnish on completion of the work a full set of Edison "Mazda" lamps of proper candle power, and also a full set of fuses.

Railings.

(114) Suitable pipe railings shall be constructed at various points, as shown on the drawings. The railings shall have $1\frac{1}{2}$-inch stanchions and $1\frac{1}{4}$-inch rails with suitable railing fittings of neat design. The railings shall be firmly bolted to the floors, walls and posts against which they abut, or preferably the stanchions shall be leaded into pipe sockets placed in the concrete.

Plumbing.

(115) A complete system of plumbing shall be installed in the headhouse, including the furnishing and placing of the various fixtures stated below, and all supply and waste pipes and appurtenances pertaining thereto. In the toilet rooms on the second floor of the headhouse there shall be placed one urinal, two water closets, two washstands, and one shower bath. In the laboratories there shall be placed one washstand and two sinks. All materials and workmanship shall be of the best quality and all work thoroughly done in accordance with the plumbing regulations of the city of Waukeegan.

Steam Heating.

(116) A complete system of steam heating shall be installed in the head house and filter wing, including all necessary piping, fittings, valves, radiators and other fixtures. The system shall be arranged to use steam from the present boiler room. Radiators shall be of approved pattern and arranged in a satisfactory manner, flat wall type radiators being used where required. Radiators and piping shall be thoroughly cleaned and painted with two good coats of bronze paint. Valves

and air cocks shall be nickel-plated. The system shall be capable of heating the office, laboratories, toilet rooms and filter gallery to 70 degrees Fahrenheit in zero weather and the remainder of the head house and filter wing to 60 degrees Fahrenheit under the same conditions.

L. — PUMPING EQUIPMENT.

Work Included.

(117) There shall be furnished and installed in the low-lift pump room in the headhouse three low-lift pumping units; two having a minimum capacity of 3 million gallons per 24 hours and one a minimum capacity of 5 million gallons per 24 hours. The units shall be arranged substantially as shown on the drawings. In case of break down the 5 million gallon pump shall be so connected that it may be used for supplying raw water.

Type of Machinery.

(118) Each unit shall consist of a horizontal centrifugal pump driven by electric motor. The specifications given previously for wash water pumps shall apply also to these units.

Drawings.

(119) The Contractor shall submit promptly for approval detail drawings of the pumps, motors piping

connections, and appurtenances which he proposes to install under this sectionoof Item 2, showing the nature of construction and material and the arrangement of all portions of the work. Such drawings shall bemmodified, if required, to make them satisfactory to the Engineer and after approval all work shall conform strictly thereto.

Compensation.

(120) The lump sum price bid under Item 2 shall include all labor, tools and materials necessary to furnish, construct and place in readiness for successful operation the settling basin, filtered-water reservoir, filters, filter equipment, chemical apparatus, filter building, piping connections, and low-lift pumping machinery complete with all appurtenances, as shown on the drawings and described in detail in the preceding specifications complete, excepting only earth and rock excavation and steel reinforcement, which will be paid for under Items 1 and 3.

ITEM 3. —STEEL REINFORCEMENT.

Work Included.

(121) Under Item 3 the Contractor shall furnish and place all steel reinforcement required and directed to be placed in the concrete under Item 2, and that re-

quired in connection with additional concrete laid under Item 4 and including expanded metal for baffles. Steel shall be of the quality and placed in the manner specified under Item 2. Metal lathing shall be included in lump sum price bid under Item 2.

Compensation.

(122) The price bid per pound under Item 3 shall include all labor, tools and appurtenances necessary to furnish and place all steel reinforcement. The weight paid for shall be computed on the basis of 489.6 pounds per cubic foot of steel for rods of the nominal sizes and lengths called for, and no allowance will be made for laps or waste. Expanded metal will be paid for at its actual weight per square foot and for the net area shown on the drawings.

ITEM 4. —ADDITIONAL CONCRETE.

Work Included.

(123) Under Item 4 the Contractor shall furnish and place any additional concrete required which is not included for payment under Item 2. This will include any extra concrete over that shown on drawings which maybbe required in the foundations of the settling basin or filtered-water reservoir, walkways, steps, retaining walls, or gutters around the outside of the filtration

plant other than shown, and any other required structures. The general specifications for concrete given under Item 2 shall apply to all work under this item.

Compensation.

The price bid per cubic yard under Item 4 shall include all labor, tools and materials necessary to furnish and lay any additional concrete complete, as specified, except the steel reinforcement in same, which will be paid for under Item 3.

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Hydraulics — Hughes and Saffords

Public Water Supplies — Hazen

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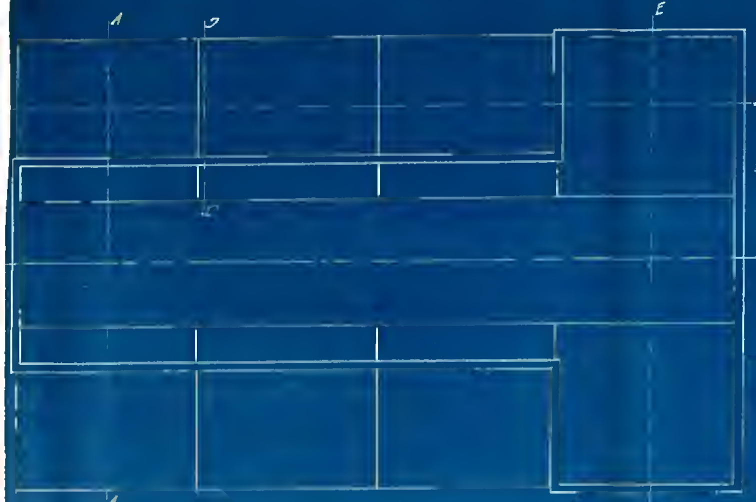
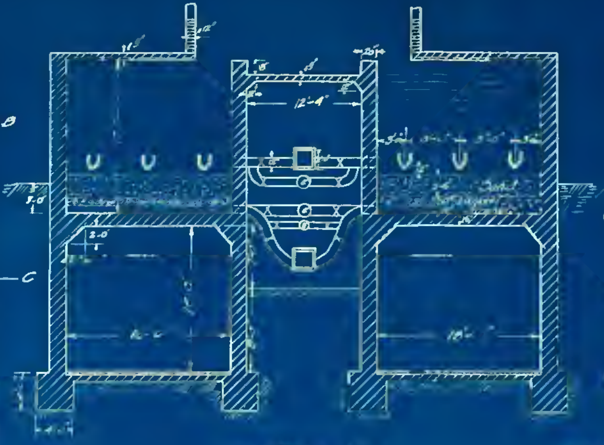
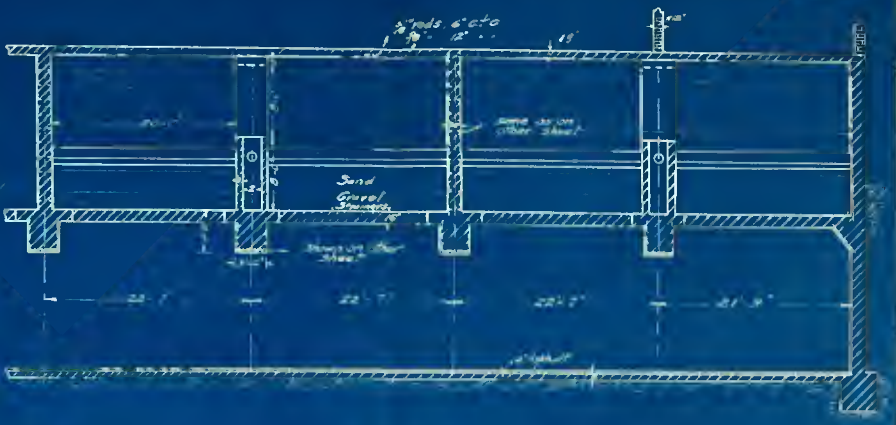


PLAN
SCALE 10'=1'

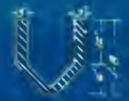


SECTION A-A

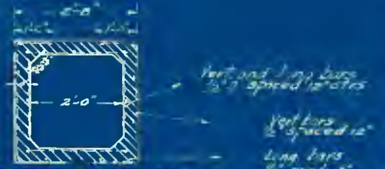
SCALE 10'=1'



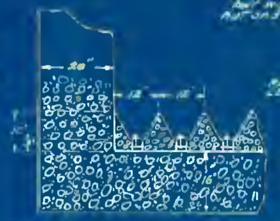
SECTION B-B



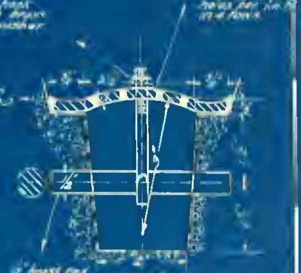
DETAIL OF WASH WATER TROUGH
SCALE 1"=1'


2'-8"
2'-0"
Vert. and Long. bars 1/2" □ spaced 12" c.to c.
Vert. bars 1/2" spaced 12"
Long. bars 1/2" sp'd 3"

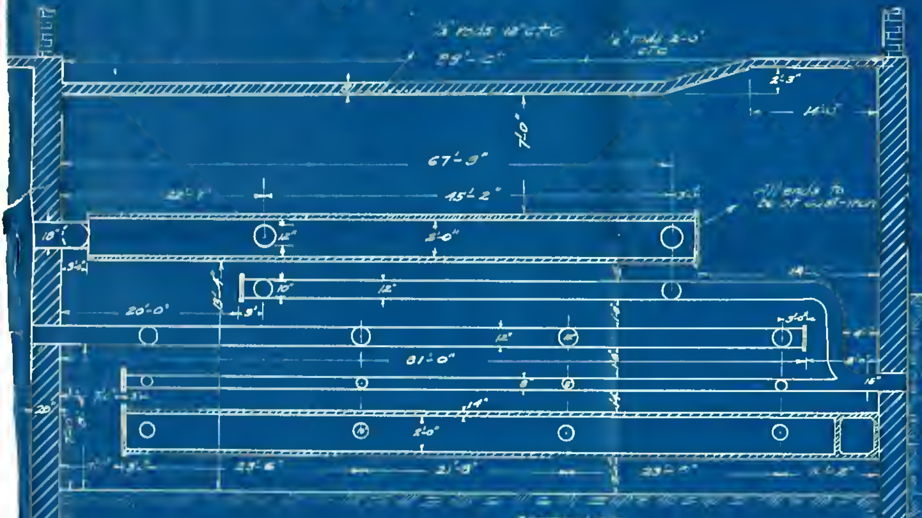
DETAIL OF RAW WATER AND EFFLUENT MAINS
SCALE 1"=2'



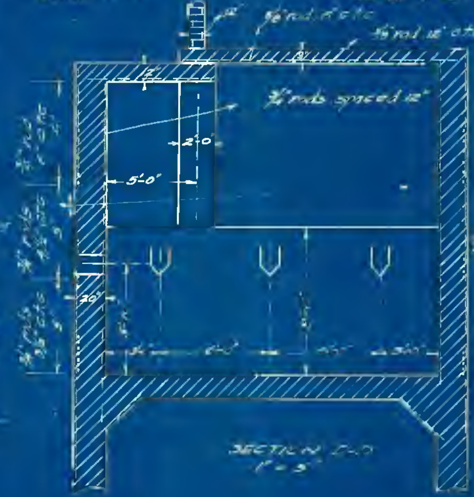
DETAIL OF STRAINER SYSTEM
SCALE 1"=2'



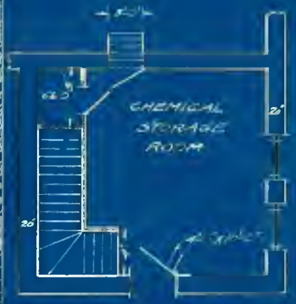
SCALE 1"=2"



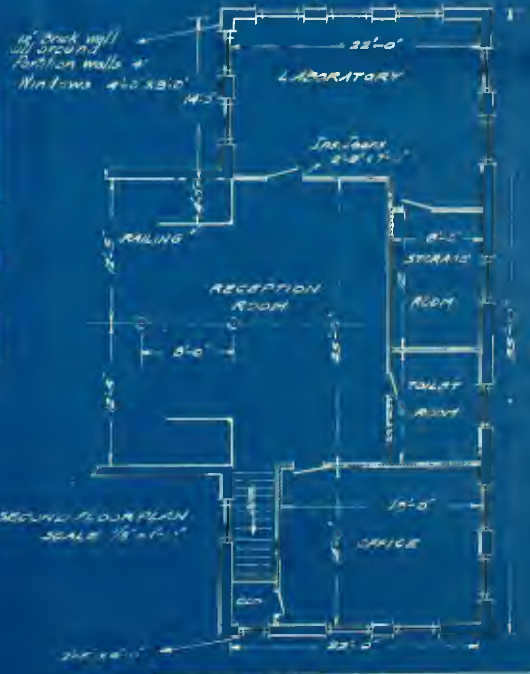
SECTION C-C
Horizontal Dimensions - 10'=1'
Detail & Vert. - 5'=1'



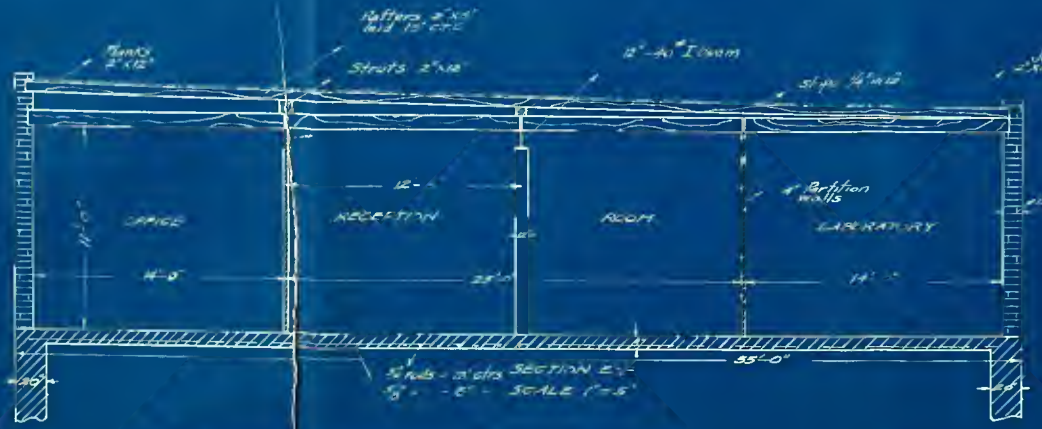
SECTION D-D
1"=5'



FIRST FLOOR PLAN
SCALE 1/8"=1'-0"

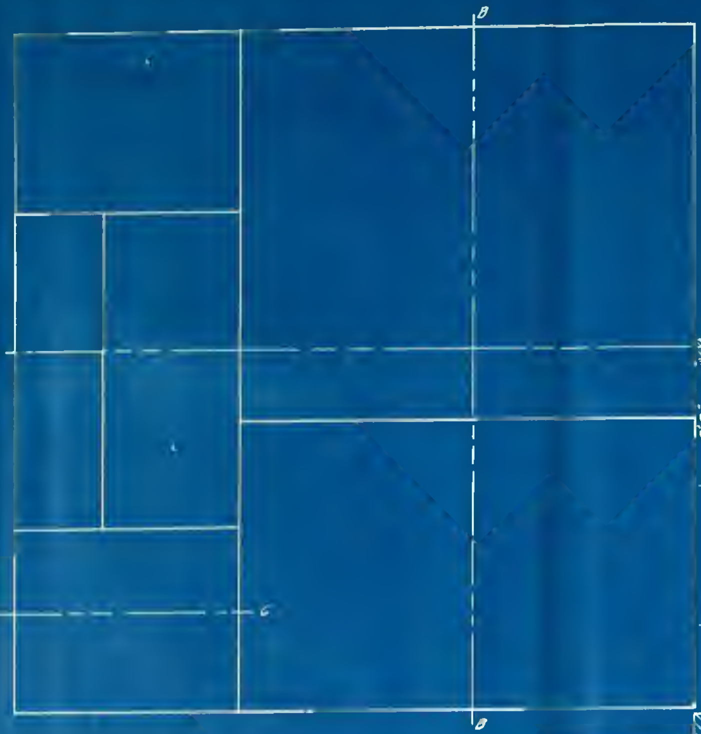


SECOND FLOOR PLAN
SCALE 1/8"=1'-0"

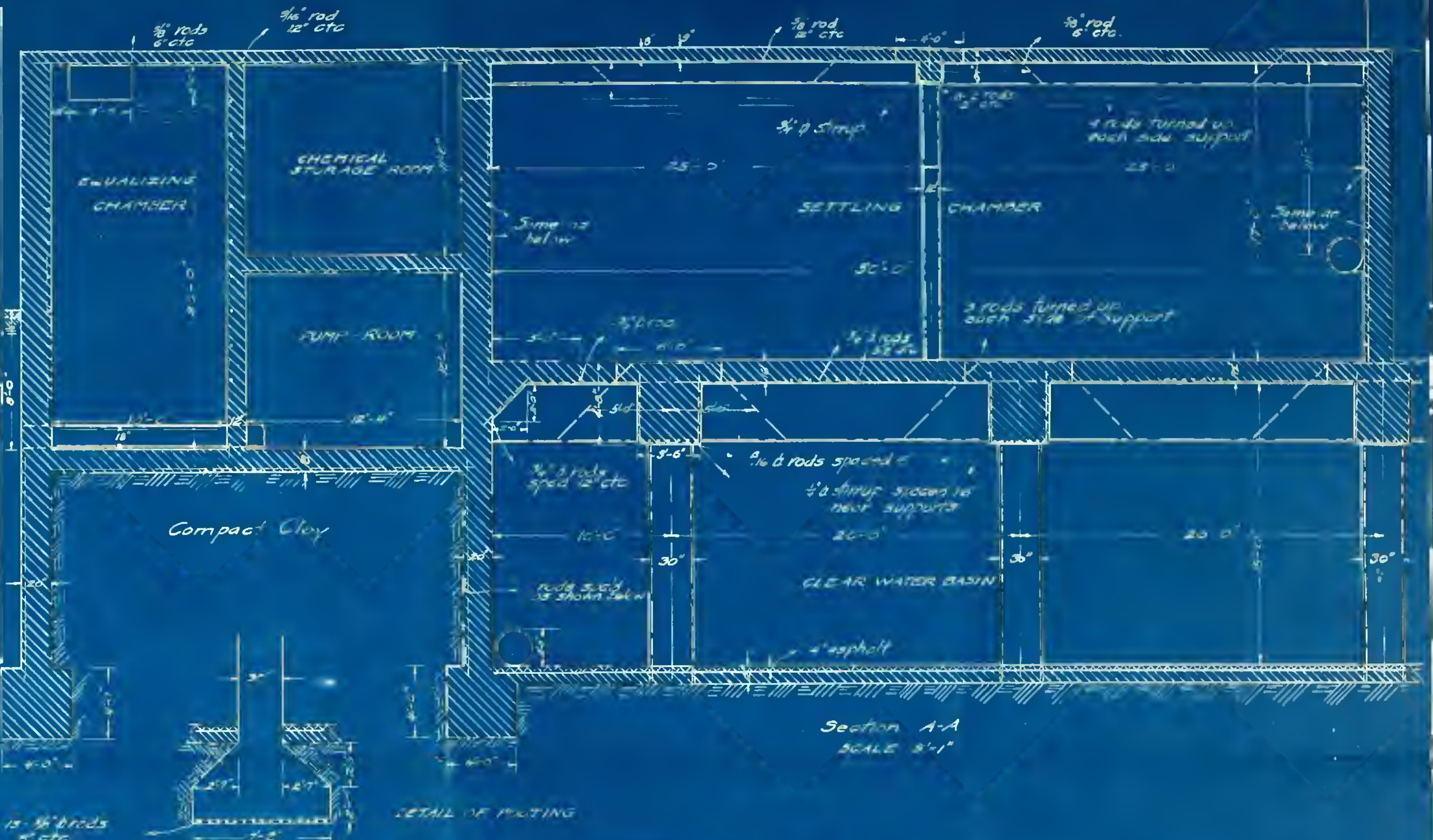


5/8" rods - 12" ctrs
5/8" - 8" -
SECTION E-E
SCALE 1"=5'

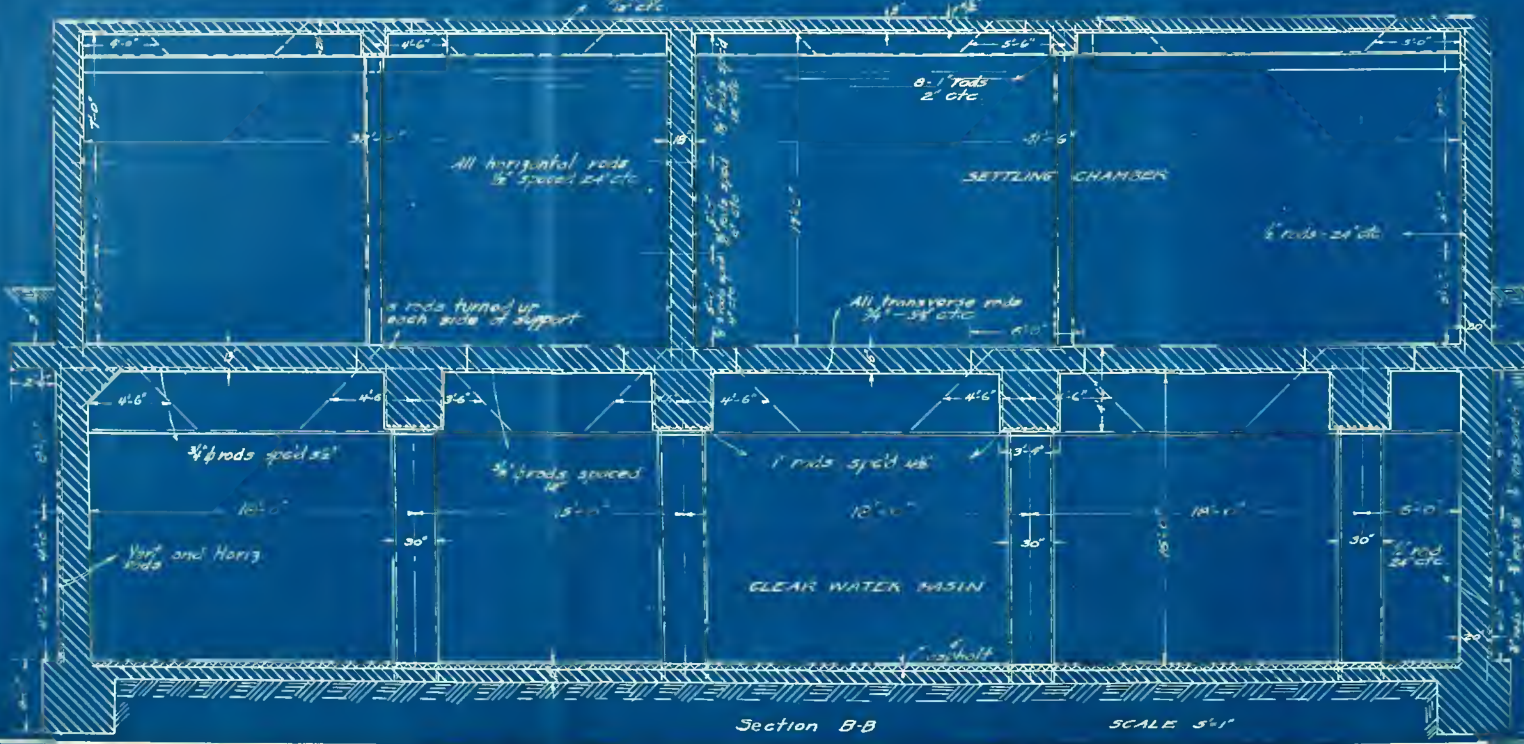
THESIS
PRESENTED BY
ARMOUR INSTITUTE OF TECHNOLOGY
Civil Engineering Department
PLAN AND SECTIONS
OF FILTER AND
HEAD HOUSE
SCALES AS SHOWN MAY, 1914



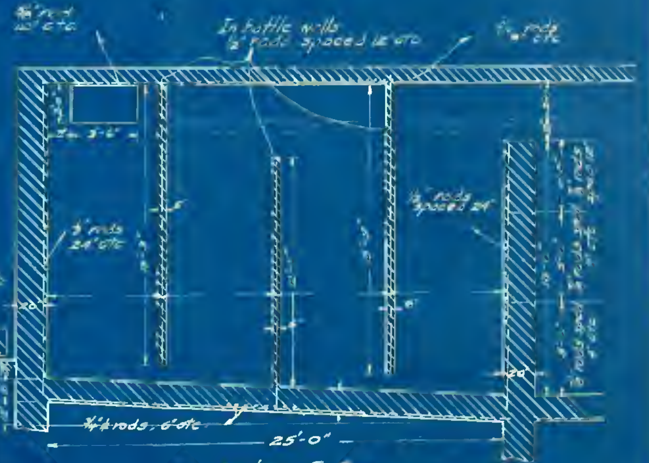
SCALE 10'-1"
PLAN



Section A-A
SCALE 5'-1"



Section B-B SCALE 5'-1"



Section C-C
MIXING CHAMBER

THESIS
PRESENTED BY
ARMOUR INSTITUTE OF TECHNOLOGY
Civil Engineering Department
PLAN AND SECTIONS
OF SETTLING AND MIXING
CHAMBERS AND CLEAR
WATER BASIN
SCALES SHOWN MAY 1914

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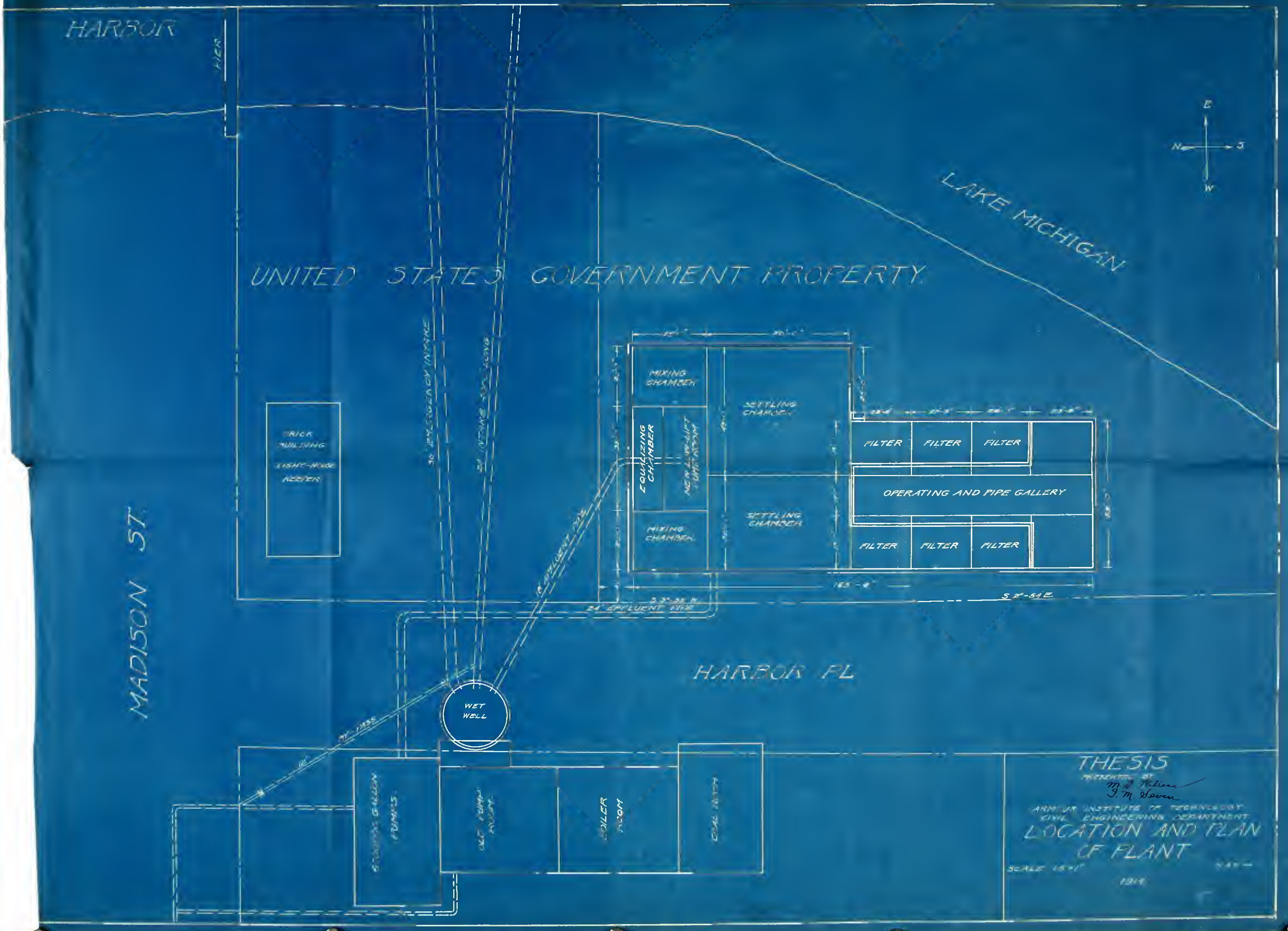

THESIS
PRESENTED BY

ARMOUR INSTITUTE OF TECHNOLOGY
CIVIL ENGINEERING DEPARTMENT

LOCATION AND PLAN OF PLANT

SCALE 1" = 40'

1914